Volume

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A DIVISION OF FALCONBRIDGE LIMITED
LAKEFIELD, ONTARIO, CANADA

Open File Report 89-1

AN INVESTIGATION OF THE RECOVERY OF ANTIMONY FROM SAMPLES SUBMITTED BY DURHAM RESOURCES INC.

PROGRESS REPORT NO. 1

by

Lakefield Research
A Division of Falconbridge Limited

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An Investigation of

THE RECOVERY OF ANTIMONY

from samples

submitted by

DURHAM RESOURCES INC.

Progress Report No. 1

Project No. L.R. 3161

NOTE:

This report refers to the samples as received.

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LAKEFIELD RESEARCH
A DIVISION OF FALCONBRIDGE LIMITED
September 24, 1986

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ABSTRACT

The flotation behaviour of St. George antimony samples in the laboratory was similar to that described for the mill.

Antimony was present in the flotation tailing as middling stibnite, native antimony, and -10 um slimes.

The test results from the various samples were as follows:

Sample	Concentrate		Head
	Grade % Sb	Recovery % Sb	Grade % Sb
Flotation feed	58	90	2.6
Mill feed 1	63	81	2.6
Mill feed 2	55	83	3.0
Native antimony	75	89	5.0

Native antimony flotation with xanthated fatty acid emulsion showed excellent promise.

INTRODUCTION

In a letter dated May 12, 1986, Mr. Victor Hendricken of Durham Resources Inc. requested assistance in optimizing mineral recovery at the Lake George antimony concentrator.

Antimony losses to final tailing were increasing.

Several mill products were shipped to Lakefield for size fraction analysis and two mill feed samples and a native antimony sample were shipped for flotation testwork.

The mineralogy of the mill feed was changing with increasing amounts of native antimony and berthierite, $FeSbS_4$.

LAKEFIELD RESEARCH

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SUMMARY

1. Head Analysis

Representative samples were removed from the mill feeds and mill products for head analysis.

Sample	% Sb	% As	% Pb	% S	% C(graphite)
Mill feed 1 *	2.63	0.32	0.007	1.97	0.08
Float feed *	2.61	0.37	0.007	-	-
Final tail *	0.44	0.33	0.009	-	-
Primary mill cyc U/F *	2.84	0.38	0.007	-	-
Native antimony	5.07	-	-	2.39	0.09
Mill feed 2	3.00	0.39	-	2.43	<0.05

* same day samples

The mill water analysis was as follows (mg/L)

Sb	18.5
Cu	<0.02
Pb	<0.05
Fe	<0.02
As	0.42
Ca	104
Mg	12.4
SiO_2	5.93

2. Size Fraction Analysis

Size fraction analyses of the flotation feed, final tailing and cyclone underflow are contained in Tables No. 1, 2 and 3.

The following points were noted:

1. 55% of the antimony in the primary mill cyclone U/F was in the -200 mesh size fraction. Removal of this fraction should reduce loss of antimony slimes.

2. Antimony recovery from the + 100 mesh fraction of the flotation feed was only 38% but this fraction contained only 2.6% of the antimony in the flotation feed and represented only 1.6% overall antimony loss in the tailing.

3. Antimony recovery from the -11 micrometer fraction of the flotation feed was 81% but this fraction contained 33.3% of the antimony in the flotation feed and represented 6.4% overall antimony loss in the tailing.

4. 38% of the antimony loss in the final tailing was in the - 11 micrometer size fraction.

5. Mineralogical examination of the size fractions of the final tailing identified stibnite, native antimony and bournonite, a lead antimony sulphide. Two other possible antimony minerals were present. Both of these minerals were fine-grained and it was difficult to determine their major optical characteristics.

The degree of liberation of the antimony minerals is shown in the following table.

Size Fraction	Wt % Liberated
+ 100 mesh	< 1%
- 100 + 200 mesh	1 - 5%
- 37 + 21 μm	80 - 85%
- 21 + 11 μm	> 95%

Stibnite was more coarse-grained than metallic antimony and there were more liberated grains of stibnite than native antimony in the + 100 and + 200 mesh size fractions.

Native antimony was considerably more abundant than stibnite in each of the five fractions.

Combined with the size fraction analysis the data showed that 37% of the antimony in the tailing was not liberated and that 38% was finer than 11 µm which accounted for 75% of the antimony in the final tailing.

Attempts to liberate the antimony in the + 400 mesh fraction would increase antimony loss in the - 11 µm fraction.

Table No. 1 - Size Fraction Analysis of Flotation Feed

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. + 100 mesh	21.6	0.32	2.6
2. - 100 + 200 mesh	19.5	1.65	12.3
3. - 200 + 400 mesh	14.6	2.93	16.4
4. - 37 + 21 µm	11.4	5.19	22.7
5. - 21 + 11 µm	9.7	3.43	12.7
6. - 11 µm (calc)	23.2	3.74	33.3
Head (Calc.)	100.00	2.61	100.0

Calculated Grades and Recoveries

Products 4 to 6	44.3	4.04	68.7

Table No. 2 - Size Fraction Analysis of Primary Mill Cyclone U/F

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. + 28 mesh	12.1	0.66	2.8
2. - 28 + 48 mesh	19.0	0.99	6.6
3. - 48 + 100 mesh	15.6	1.66	9.1
4. - 100 + 200 mesh	13.8	2.61	12.7
5. - 200 + 400 mesh	10.3	3.89	14.1
6. - 37 + 21 µm	8.0	6.46	18.2
7. - 21 + 11 µm	7.0	4.15	10.2
8. - 11 µm (calc)	16.2	4.60	26.3
Head (Calc.)	100.00	2.84	100.0

Calculated Grades and Recoveries

Products 6 to 8	31.2	4.97	54.7

Table No. 3 - Size Fraction Analysis of Final Tailing

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb	A	B
1. + 100 mesh	17.8	0.24	9.7	61.8	1.64
2. - 100 + 200 mesh	21.8	0.31	15.4	21.0	2.59
3. - 200 + 400 mesh	16.6	0.41	15.5	15.9	2.61
4. - 37 + 21 µm	10.7	0.55	13.4	9.93	2.25
5. - 21 + 11 µm	10.0	0.36	8.2	10.8	1.38
6. - 11 µm (calc)	23.1	0.72	37.8	19.2	6.39
Head (Calc.)	100.00	0.44	100.0	-	16.85

A : % Sb loss in final tail of each size fraction (individual)
B : % Sb loss in final tail of each size fraction (overall)

3. Mineralogy

Stibnite, native antimony and berthierite, $FeSbS_4$, were identified in Mill Feeds 1 and 2. Pyrite was the major iron sulphide mineral in Mill Feed 1 but marcasite was the major iron sulphide mineral in Mill Feed 2 as shown below:

Weight % Iron Sulphide Minerals in Mill Feeds

Feed	Pyrite	Marcasite	Pyrrhotite	Uncertain
1	45	35	15	5
2	20	70	5	5

The external surfaces and fracture surfaces of the stibnite in Mill Feed 2 were darker in colour and slightly rougher than in Mill Feed 1.

4. Flotation Feed

The flotation feed responded well to standard flotation conditions in Test 5.

A sample of 3.4 L of flotation feed pulp containing about 2 kg solids was conditioned with 500 g/t lead nitrate to activate the antimony minerals which were collected with 60 g/t 3477 in 10 minutes rougher flotation. The rougher concentrate was cleaned 3 times with small amounts of lead nitrate.

The rougher concentrate assayed 20% Sb at 94% recovery. Cleaning was efficient and the third cleaner concentrate asayed 58% Sb at 90% recovery.

5. Mill Feed 1

The flotation response of mill feed 1 was inferior to that of the flotation feed.

A total of fifteen tests were conducted in which the following parameters were examined:

1. primary grind
2. regrind (scavenger concentrate)
3. activators: $Pb(NO_3)_2$ and $Cu\ SO_4$
4. collectors: cyanamid 3477, cyanamid 3501, minerec 2044, xanthate, and xanthated fatty acid emulsions
5. pH modifiers and depressants: SO_2 and A3-3 (mixture of alum, Na_2SO_3 and NaSil)

The flotation conditions and results are contained in Figure No. 1 and Table No. 4.

Concentrate grades of 60% Sb were produced in several batch tests at 82 to 84% recovery. Recovery decreased rapidly above 60% Sb.

Typical flotation characteristics were as follows:

1. Initial, rapid, bright, high-grade stibnite flotation in roughing and cleaning.
2. After this initial surge the respective cells contained considerably coarser, liberated, slightly darker or duller stibnite.
3. A variety of chemicals would float this stibnite: lead nitrate, SO_2, additional collector and even octyl alcohol. Lead nitrate was the most efficient of these reagents and floated a high grade stibnite concentrate with pyrite as the main diluent.
4. Nursing the flotation through each stage with lead nitrate resulted in a gradual loss of Sb recovery and a final grade of less than 65% Sb.

Grind was not examined extensively. Overgrinding and sliming the antimony minerals was of major concern as shown by the size fraction analysis of the final tailings. The presence of numerous small attachments of antimony minerals on quartz and pyrite was quite obvious.

There was no reduction in flotation tailing loss when the primary grind was increased from 60 to 75% - 200 mesh which suggested that a coarser grind should be examined. A light regrind after one or two stages of cleaning might be advantageous.

A variety of collectors were examined and $CuSO_4$ was substituted for lead nitrate as an antimony mineral activator.

Sequential flotation with 3477 followed by xanthated fatty acid showed some promise in test 19 and should be examined further. The intent would be to float and clean the stibnite and native antimony in separate circuits. It should be noted that mineral identification using the binocular microscope was not easy. There was a complete range of antimony minerals from silvery white to dull grey, and similar for iron sulphides.

The pulp consumed SO_2 rapidly, making it an uneconomical reagent. Increasing the pH with any reagent would increase Sb solubility and recovery which possibly occurred with the depressant mixture of alum, Na_2SO_3 and sodium silicate.

Table No. 4 - Flotation Conditions and Results Mill Feed 1

Test	Grind	$Pb(NO_3)_2$		Collector			Depressant			Cleaner Concentrate		
No.	% -200M	Ro g/t	Cl g/t	Type	Ro g/t	Cl g/t	Type	Ro g/t	Cl g/t	Wgt %	Assay % Sb	% Dist Sb
1	60	500	175	3477	60	15	-	-	-	3.4	59	80
2	60	500	175	3477	60	15	-	-	-	3.7	58	85
3	75	500	175	3477	60	15	-	-	-	3.5	60	82
8	75	500	175	2044	80	15	-	-	-	3.7	58	84
9	75	1250*	175	325	140	20	-	-	-	4.8	41	80
18	75	300*	-	FA3/350	25	-	A3-3	150	-	-	-	-
19	75	1000	-	3477	55	-	A3-3	200	-	2.4	65	58
22	75	750	175	3477	120	20	-	-	-	4.8	46	85
23	75	500	50	3501	100	-	A3-3	-	50	3.5	60	81
24	75	250*	-	3477	40	-	-	-	-	-	-	-
25	75	700	100	FA1/325	100	-	A3-3	500	500	3.3	57	77
27	75	900	25	3477	160	20	SO_2	300	300	3.2	63	81
28	75	1000	175	3477	120	-	A3-3	-	25	3.9	54	84
29	75	750	200	2044	120	15	-	-	-	3.6	59	83
30	75	750	200	2044	120	15	-	-	-	4.2	53	85

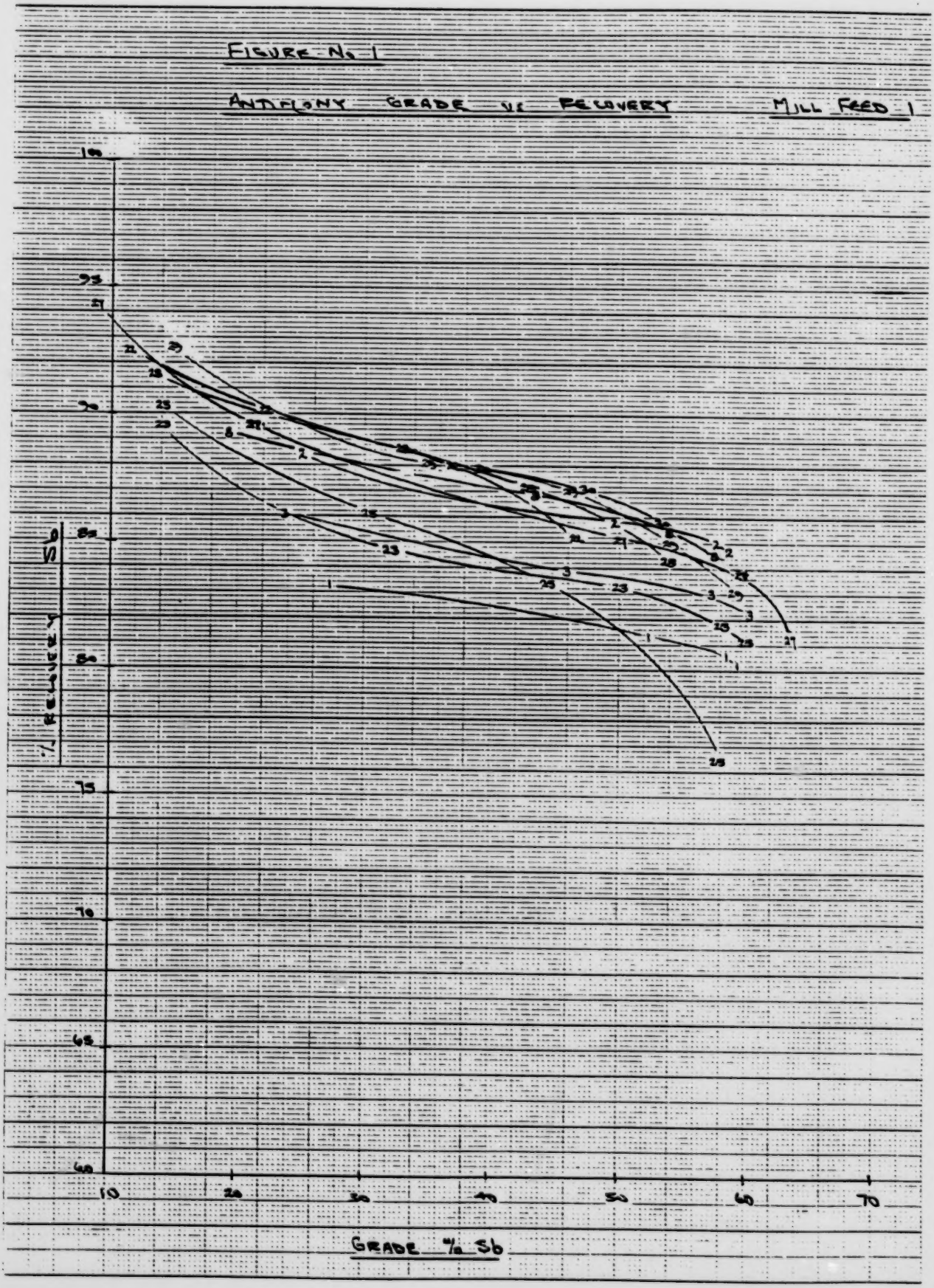
A3-3 is a mixture of alum, Na_2SO_3 and NaSil

* $CuSO_4$

** regrind the scavenger concentrate

FIGURE No. 1

ANTIMONY GRADE VS RECOVERY MILL FEED 1



5.1 Mineralogy of Test Products

Mineralogical examination of polished sections of selected products from Test 8 showed some very interesting results:

Stibnite was the major mineral in the cleaner concentrate. Quartz was the main diluent and all of the quartz either contained inclusions or carried surface attachments of stibnite. The inclusions/attachments were smaller than the quartz grains by a factor larger than 5. A regrind of the concentrate would be required to liberate the attachments or the amount of activator/collector should be reduced to reduce middling flotation, with attendant loss of recovery. Native antimony was not identified.

Native antimony was the major antimony mineral in the flotation tailing and accounted for an estimated 80-85 of the antimony in the tailing.

The reagent balance in Test 8, lead nitrate activation and collection with Minerec 2044 did not recover native antimony.

6. Mill Feed 2

Mill feed 2 was quite refractory and rougher additions of 600 g/t lead nitrate and 160 g/t 3477 were required to float 90% of the antimony into the rougher concentrate. The rougher concentrate was cleaned twice with additional lead nitrate and collector to produce a cleaner concentrate assaying 55% Sb at 33% recovery in Test 26.

As noted in the mineralogical examination of the head samples, the stibnite in mill feed 2 was darker and rougher than in mill feed 1.

7. Native Antimony

Excellent flotation results were achieved on the native antimony sample in Test 12. $CuSO_4$ was used to activate the antimony minerals which were

collected with a xanthated fatty acid. A mixture of alum, Na_2SO_3 and sodium silicate was used to depress pyrite and silicates. The cleaner concentrate assayed 75% Sb at 89% recovery from a calculated head of 5% Sb. The rougher tailing assayed 0.38% Sb.

Lead nitrate was used in place of $CuSO_4$ in Test 15 and the xanthated fatty acid emulsion was stabilized. A rougher concentrate assaying 33% Sb at 91% recovery was produced in 5 minutes flotation. The concentrate was not cleaned.

The sample responded very poorly to the normal mill reagents of lead nitrate and 3477.

7.1 Mineralogy of Test Products

Mineralogical examination of polished sections of selected products from Test 4 showed the following characteristics:

The normal mill reagent combination of lead nitrate and 3477 recovered about 50% of the antimony in the sample. The major Sb minerals were stibnite and native antimony in the ratio of approximately 5 to 1.

A combination of $CuSO_4$ and xanthate floated a high grade scavenger concentrate which assayed 48% Sb at 14% recovery. The major Sb minerals were stibnite and native antimony in the ratio of approximately 2 to 1. Xanthate was definitely a more efficient native antimony collector than 3477.

The ratio of stibnite to native antimony in the flotation tailing was about 1 to 1.

DISCUSSION AND RECOMMENDATIONS

The results showed three problem areas in the flotation of the St. George antimony.

1. Liberation: loss of antimony as small attachments or inclusions on gangue minerals especially quartz.

2. Slime loss: loss of antimony in the minus 11 μm size fraction.

3. Native antimony and berthierite: the standard mill reagents of lead nitrate and 3477 were not an efficient reagent combination for flotation of native antimony and berthierite.

The combination of mineral losses as middlings and slime loss is unfortunate but quite common. The small size of the antimony attachments suggested that liberation would be difficult without overgrinding and increasing slime loss. Regrinding after 1 or 2 stages of cleaning should be examined after a primary grind of about 60% - 200 mesh.

A xanthated fatty acid emulsion showed excellent promise for native antimony flotation. Stibnite flotation with 3477 followed by native antimony flotation with xanthated fatty acid should be examined in more detail. Pyrite flotation with the xanthated fatty acid was the major problem which possibly could be solved with lime depression or depression with other reagents such as A3-3. Berthierite may float with the native antimony.

Other collectors such as mercaptobenzothiazole AP404 which was originally developed for lead carbonate flotation should also be examined.

Mineralogical examination of selected test products must be emphasized. Examination of the flotation products under the binocular microscope at 90X magnification was informative for silicate/sulphide discrimination but quite difficult to distinguish within and between the range of antimony minerals and iron sulphide minerals.

REAGENT PREPARATION

Depressant A3-3

Add 1 gram alum, 2 g Na_2SO_3 and 3 g Na silicate to 300 mL water and agitate for 10 minutes after each addition in series.

Xanthated Fatty Acid

Mix 0.8 g AX350 and 0.2 g FA3 in 100 mL water at high agitation in blender for 10 minutes at 50°C. This emulsion should be stablished with 10% Lannagol OP6 or it will separate. FA1 is a less refined fatty acid and should provide similar results.

SAMPLE PREPARATION

18 x 22.5 L pails with a shipping weight of 200 kg were received at Lakefield on May 27, 1986. The pails were identified as follows:

mill feed	4 pails (108 Kg)
flotation feed	4 pails
final tailing	4 pails
primary mill cyclone U/F	3 pails
native antimony	1 pail (22 kg)
mill water	2 pails

The mill feed and active antimony sample were slightly moist and were oven dried before being crushed to - 10 mesh and riffled into test charges (27 x 2 kg mill feed and 20 x 1 kg native antimony) and head samples.

The flotation feed, final tailing and cyclone U/F samples were pulped at high density in 100 L drums and sampled to recover head samples for analysis and test charges as required.

The mill water was received in several plastic containers inside the two pails. The containers were combined and sampled for analysis.

On June 24, 1986, a second sample of mill feed was received in one 22.5L pail. The sample was dried, crushed to - 10 mesh and riffled into 13 x 2 kg test charges and a head sample. The sample was labelled mill feed 2.

Size Analysis

Float Feed

Size	% Retained Individual	% Retained Cumulative	% Pasing Cumulative
+ 65 mesh	11.4	11.4	88.6
100 mesh	10.2	21.6	78.4
150 mesh	10.4	32.0	68.0
200 mesh	9.1	41.1	58.9
270 mesh	7.7	48.8	51.2
400 mesh	6.9	55.7	44.2
29.5 µm	4.9	60.6	39.4
20.6 µm	6.5	67.1	32.9
13.2 µm	6.3	73.4	26.6
10.9 µm	3.4	76.8	23.2
- 10.9 µm	23.2	100.0	-
Total	100.0	-	-

Specific Gravity 2.84

Size Analysis

PM Cyclone U/F

Size	% Retained		% Pasing
	Individual	Cumulative	Cumulative
+10 mesh	1.1	1.1	98.9
14 mesh	1.9	3.0	97.0
20 mesh	3.0	6.0	94.0
28 mesh	6.1	12.1	87.9
35 mesh	7.4	19.5	80.5
48 mesh	9.6	29.1	70.9
65 mesh	8.2	37.3	62.7
100 mesh	7.4	44.7	55.3
150 mesh	7.4	52.1	47.9
200 mesh	6.4	58.5	41.5
270 mesh	5.4	63.9	36.1
400 mesh	4.9	68.8	31.3
29.3 μm	3.4	72.2	27.8
20.5 μm	4.6	76.8	23.2
14.1 μm	4.5	81.3	18.7
10.9 μm	2.5	83.8	16.2
-10.9 μm	16.2	100.0	-
Total	100.0	-	-

Specific Gravity 2.86

Size Analysis

Final Tail

Size	% Retained		% Pasing
	Individual	Cumulative	Cumulative
+65 mesh	7.6	7.6	92.4
100 mesh	10.2	17.8	82.2
150 mesh	11.6	29.4	70.6
200 mesh	10.2	39.6	60.4
270 mesh	8.9	48.5	51.5
400 mesh	7.7	56.2	43.8
29.9 um	3.9	60.1	39.9
20.9 um	6.8	66.9	33.1
14.4 um	6.5	73.4	26.6
11.1 um	3.5	76.9	23.1
-11.1 um	23.1	100.0	-
Total	100.0	-	-

Specific Gravity 2.80

DETAILS OF TESTS

Flotation Feed

Test No. 5

Purpose: To repeat conditions of test 1 on flotation feed pulp.

Procedure: Sample 3.4 L of flotation feed pulp. Dilute to flotation density with Lakefield tap water and float as indicated below.

Feed: 2000 grams flotation feed sample

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Rougher	250	40	10	-	2	5	7.8
	250	20	-	-	2	5	-
Scavenger	250	40	-	-	2	5	-
1st Cleaner 1	-	5	-	-	1	5	7.8
1st Cleaner 2	100	5	-	-	2	3	-
2nd Cleaner	50	5	-	-	2	5	-
3rd Cleaner	25	-	-	-	2	4	-

Observations:

Scavenger Tail — Finely disseminated antimony in quartz.
Some free but pitted antimony minerals.

Scavenger Concentrate — Coarse stibnite middlings with quartz.

1st Cleaner Tail — Stibnite middlings with quartz

3rd Cleaner Concentrate — Some stibnite middling with quartz
Small amount of stibnite middling with pyrite
A few well formed stibnite crystals.

Test No. 5 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 3rd Cl Conc	4.05	57.5	90.7
2. Sb 3rd Cl Tail	0.38	7.18	1.1
3. Sb 2nd Cl Tail	1.83	1.86	1.3
4. Sb 1st Cl Tail	5.53	0.56	1.2
5. Sb Scav Conc	3.80	0.76	1.1
6. Sb Scav Tail	84.41	0.14	4.6
Head (Calc.)	100.00	2.57	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.43	53.2	91.8
Products 1 to 3	6.26	38.2	93.1
Products 1 to 4	11.79	20.5	94.3
Products 1 to 5	15.59	15.7	95.4
Products 5 and 6	88.21	0.17	5.7
Flotation Tailing water		8.2 mg/L	

Mill Feed 1

Test No. 1

Purpose: To examine the flotation characteristics of the mill feed.

Procedure: As below.

Feed: 2 Kg -10 mesh mill feed 1

Grind: 20 minutes in ball mill at 66% solids

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	20	-	-	7.8
Rougher 1	250	40	5	-	2	5	7.5
Rougher 2	250	20	2.5	-	2	5	-
Scavenger *	250	40	-	-	2	5	-
1st Cleaner 1	-	5	-	-	1	5	7.9
1st Cleaner 2	100	5	-	-	2	3	-
2nd Cleaner	50	5	-	-	2	5	7.2
3rd Cleaner	25	-	-	-	2	4	7.3

Observations:

Scavenger Concentrate

Some coarse liberated stibnite.
Some coarse stibnite with small quartz attachments.
Middling primarily with quartz

Scavenger Tailing

Stibnite disseminated in quartz.
Some liberated stibnite (?) but pitted.

Test No. 1 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cl Conc	3.42	59.3	80.3
2. 3rd Cl Tail	0.06	10.4	0.3
3. 2nd Cl Tail	0.45	3.90	0.7
4. 1st Cl Tail	3.82	1.35	2.0
5. Scav Conc	6.72	3.35	8.9
6. Scav Tail	85.53	0.23	7.8
Head (Calc.)	100.00	2.53	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.48	58.5	80.6
Products 1 to 3	3.93	52.2	81.3
Products 1 to 4	7.75	27.1	83.3
Products 1 to 5	14.47	16.1	92.2
Products 5 to 6	92.25	0.46	16.7

Particle Size	% Retained Individual	% Retained Cumulative	% Passing Cumulative
+ 48M	2.9	2.9	97.1
65	3.5	6.4	93.6
100	8.5	14.9	85.1
150	12.6	27.5	72.5
200	12.2	39.7	60.3
270	10.0	49.7	50.3
400	8.6	58.3	41.7
29.9 um	5.0	63.3	36.7
20.9	6.7	70.0	30.0
14.4	6.1	76.1	23.9
11.1	3.3	79.4	20.6
- 11.1	20.6	100.0	-
Total	100.0	-	-

Specific Gravity 2.81

Mill Feed 1

Test No. 2

Purpose: To repeat conditions of test 1 but use mill water throughout

Procedure: As outlined below. Save flotation tailing filtrate for Sb analysis

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 20 minutes at 65% solids in ball mill

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	20	-	-	7.9
Rougher 1	250	40	5	-	2	5	7.6
Rougher 2	250	20	-	-	2	5	-
Scavenger *	250	40	-	-	2	5	-
1st Cleaner 1	-	5	-	-	1	5	7.6
1st Cleaner 2	100	5	-	-	2	3	-
2nd Cleaner	50	5	-	-	2	5	7.3
3rd Cleaner	25	-	-	-	2	4	7.4

Observations:

Scavenger Concentrate Liberated stibnite and considerable middling stibnite primarily with quartz.
Recommend regrind in closed circuit.

Scavenger Tailing Range of middling stibnite (fine to coarse) Primarily with quartz.

Test No. 2 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cl Conc	3.68	58.5	84.7
2. 3rd Cl Tail	0.07	9.75	0.3
3. 2nd Cl Tail	0.64	3.31	0.8
4. 1st Cl Tail	4.62	1.45	2.6
5. Scav Conc	2.11	3.79	3.2
6. Scav Tail	88.8	0.24	8.4
Head (Calc.)	100.00	2.54	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.75	37.6	85.0
Products 1 to 3	4.39	49.7	85.8
Products 1 to 4	9.01	24.9	88.4
Products 1 to 5	11.02	21.1	91.6
Products 5 to 6	90.99	0.32	11.6
Flot Tail Water mg/l		4.5	

Mill Feed 1

Test No. 3

Purpose: To repeat conditions of test 1 with a finer grind

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 59% solids in lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	-
Rougher 1	250	40	10	-	2	5	7.8
Rougher 2	250	20	-	-	2	5	-
Scavenger *	250	40	-	-	2	5	-
1st Cleaner 1	-	5	-	-	1	5	7.8
1st Cleaner 2	100	5	-	-	2	3	-
2nd Cleaner	50	5	-	-	2	5	7.4
3rd Cleaner	25	-	-	-	2	4	7.4

Test No. 3 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cl Conc	3.54	60.1	82.3
2. 3rd Cl Tail	0.21	8.87	0.4
3. 2nd Cl Tail	0.98	2.35	0.9
4. 1st Cl Tail	4.62	1.22	2.2
5. Scav Conc	5.85	3.27	7.4
6. Scav Tail	84.80	0.20	6.5
Head (Calc.)	100.00	2.59	100.0

Flotation Tailing Water Sb, mg/L 2.2

Calculated Grades and Recoveries

Products 1 and 2	3.75	57.2	83.0
Products 1 to 3	4.78	45.9	83.9
Products 1 to 4	9.35	23.8	86.1
Products 1 to 5	15.20	15.9	93.5
Products 5 to 6	90.65	0.40	13.9

Particle Size	% Retained Individual	% Retained Cumulative	% Passing Cumulative
+ 100M	3.8	3.8	96.2
150	7.2	11.0	89.0
200	13.6	24.6	75.4
38.3µm	18.9	43.5	56.5
29.7	10.8	54.3	45.7
20.7	9.5	63.8	36.2
14.3	7.9	71.7	28.3
11.0	4.0	75.7	24.3
- 11.0	24.3	100.0	-
Total	100.0	-	-

Specific Gravity 2.81

Mill Feed 1

Test No. 6

Purpose: To examine the flotation response of the mill feed after a stage grind to minus 100 mesh.

Procedure: As below.

Feed: 2 Kg -10 mesh mill feed

Grind: 20 + 6 + 4 minutes in rod mill at 66% solids

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	20	-	-	-
Screen at 100 mesh Grind O/S 1 min per 200 g		-	-	6	-	-	-
Screen at 100 mesh Grind O/S 1 min per 200 g		-	-	4	-	-	-
Rougher 1	250	-	-	-	2	-	7.4
	-	40	5	-	1	5	-
Rougher 2	250	-	-	-	2	-	7.4
	-	20	-	-	1	5	-
Rougher 3	250	-	-	-	2	-	7.2
	-	20	-	-	1	5	-
Rougher 4	250	-	-	-	2	-	7.2
	-	40	-	-	1	5	-

Test No. 6 - Continued

Observations:	(binocular microscope)
Ro Conc #1	gangue; mostly pyrite - some quartz Some middling with both pyrite and quartz
Ro Conc #2	coarser than #1 more pyrite some middling mainly with quartz
Ro Conc #4	liberated Sb some middling with quartz more quartz
Ro Tail	very little Sb as small attachments to quartz
Comments	Stage grinding did not reduce amount of minus 10 micron material and did not improve flotation performance.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Ro Conc 1	2.81	58.6	42.6
2. Ro Conc 3	2.83	23.1	25.7
3. Ro Conc 3	4.74	10.8	20.0
4. Ro Conc 4	4.33	2.33	4.0
5. Ro Tail	85.29	0.23	7.7
Head (Calc.)	100.00	2.55	100.0

Flotation Tailing Water Sb, mg/L 2.2

Calculated Grades and Recoveries

Products 1 and 2	5.64	30.8	68.3
Products 1 to 3	10.38	21.7	88.3
Products 1 to 4	14.71	16.0	92.3

Test No. 6 - Continued

Particle Size	% Retained		% Passing
	Individual	Cumulative	Cumulative
+ 100M	2.5	2.5	97.5
150	18.1	20.6	79.4
200	16.6	37.2	62.8
38.3 um	15.4	52.6	47.4
29.7	8.2	60.8	39.2
20.7	7.4	68.2	31.8
14.3	s6.4	74.6	25.4
11.0	3.2	77.8	22.2
- 11.0	22.2	100.0	-
Total	100.0	-	-

Specific Gravity 2.81

Mill Feed 1

Test No. 8

Purpose: To repeat conditions of Test 3 but use Minerec 2044 in place of 3477.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	7.6
Rougher 1	250	40	20	-	2	5	-
Rougher 2	250	40	-	-	2	5	-
Scavenger	250	40	-	-	2	5	-
1st Cleaner	-	5	-	-	1	5	7.5
	100	5	-	-	2	3	-
2nd Cleaner	50	5	10	-	2	5	7.0
3rd Cleaner	25	-	-	-	2	4	-

Test No. 8 - Continued

Observations:	(binocular microscope)
Scavenger Tail	some middling with quartz considerable liberated antimony mineral(s).
Scavenger Conc	coarse liberated antimony mineral(s) some middling with quartz
1st Cl Tail	some middling with quartz finely intergrown or oxidized
3rd Cl Conc	initial froth : clean >65% Sb extremely rapid flotation, trapped gangue in froth quartz major gangue component.
	(Polished Grain Mounts)
3rd Cl Conc	Stibnite was the major Sb mineral present but two other minerals of Sb also were present. One of these appeared to be the Fe Sb sulfide berthierite and the other was a Pb Sb sulfide, possibly bournonite or similar mineral. The major diluent was quartz. All of the quartz either contained inclusions or carried surface attachments of stibnite. The inclusions/attachments were smaller than the host particle by a factor larger than 5. Pyrite was present in trace amount, i.e. les than one half percent. Native antimony was not identified.
Scav Conc	The major Sb mineral was stibnite, present as liberated particles measuring from 200 to smaller than 15 micrometers and as inclusions in non-opaque gangue (largely quartz) generally smaller than 20 micrometers. Traces (<1 percent) of berthierite and possible bournonite also were present.
Scav Tailing	Native antimony was the major Sb mineral present but stibnite and berthierite also were present. Stibnite represented an estimated 10 to 15 percent and berthierite less than 5 percent of the Sb minerals in the sample. The host mineral was quartz. An estimated 60 % of the opaque minerals were liberated.

Test No. 8 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cleaner Conc.	3.68	57.5	84.5
2. 3rd Cleaner Tail.	0.30	8.25	1.0
3. 2nd Cleaner Tail.	1.04	3.28	1.4
4. 1st Cleaner Tail	6.85	0.84	2.3
5. Scavenger Conc.	4.95	2.11	4.2
6. Scavenger Tail.	83.18	0.20	6.6
Head (Calc.)	100.00	2.50	100.0

Flotation Tailing Water Sb, mg/L 2.2

Calculated Grades and Recoveries

Products 1 and 2	3.98	53.8	85.5
Products 1 to 3	5.02	43.3	86.9
Products 1 to 4	11.87	18.8	89.2
Products 1 to 5	16.82	13.9	93.4
Products 5 and 6	88.13	0.31	10.8

Mill Feed 1

Test No. 9

Purpose: To repeat conditions of Test 3 using $CuSO_4$ and A325 instead of $Pb(NO_3)_2$ and 3477.

Procedure: As outlined below. Combine all concentrates for cleaning

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$CuSO_4$	A325	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	-
Rougher 1	250	-	20	-	2	-	7.3
	-	20	-	-	1	5	-
Rougher 2	250	-	-	-	2	-	7.0
	-	20	20	-	1	5	-
Rougher 3	250	-	-	-	2	-	-
	-	20	10	-	1	5	-
Rougher 4	250	-	-	-	2	-	-
	-	20	10	-	1	2	-
Rougher 5	250	-	-	-	2	-	-
	-	20	20	-	1	2	-
	-	20	-	-	1	2	-
	-	20	-	-	1	2	-
1st Cleaner	-	5	-	-	1	5	-
	100	-	-	-	2	-	-
	-	5	10	-	1	3	7.0
	-	5	-	-	1	2	-
2nd Cleaner	50	-	-	-	2	-	-
	-	5	-	-	1	5	-
3rd Cleaner	25	-	-	-	2	3	-

Test No. 9 - Continued

Observations:

Ro Conc 1	very pyritic very little stibnite
Ro Conc 2	similar to 1 fine stibnite
Ro Conc 3	stibnite floating with quartz
Ro Tail 3	liberated coarse stibnite - middling
Ro Conc 4 and 5	relatively clean stibnite
Comments:	$CuSO_4$ - sodium ethyl xanthate floated pyrite with stibnite but still left 9% Sb in tailing.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cleaner Conc.	4.79	40.6	80.1
2. 3rd Cleaner Tail.	0.88	4.70	1.7
3. 2nd Cleaner Tail.	2.80	3.36	3.9
4. 1st Cleaner Tail.	7.82	1.54	5.0
5. Ro Tail	83.71	0.27	9.3
Head (Calc.)	100.00	2.43	100.0

Calculated Grades and Recoveries

Products 1 and 2	5.67	35.0	81.8
Products 1 to 3	8.47	24.6	85.7
Products 1 to 4	16.29	13.5	90.7

Mill Feed 1

Test No. 18

Purpose: To repeat conditions of Test 12 on mill feed sample

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne					Time, minutes			pH
	A3-3	$CuSO_4$	A350/FA3	MIBC	Octyl Alcoh.	Grind	Cond.	Froth	
Grind	-	-	-	-	-	30	-	-	-
Condition	150	-	-	-	10	-	5	-	7.9
Rougher	-	300	25	55	-	-	2	8	7.3

Observations: The froth was very pyritic. Test products discarded. A similar test was conducted with A3-3 at 300 g/t and $CuSO_4$ at 150 g/t with 15 g/t A350/FA3 which was also very pyritic and discarded.

Mill Feed 1

Test No. 19

Purpose: To investigate staged flotation with 3477 followed by xanthated fatty acid.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	A3-3	$Pb(NO_3)_2$	3477	A350 / FA3	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Condition	200	-	-	-	-	2	-	7.9
Rougher 1	-	250	40	-	-	2	5	7.8
Rougher 2	-	250	15	-	-	2	4	-
Scavenger 1	-	250	-	5	-	1	2	-
Scavenger 2	-	250	-	5	-	1	2	-
Scavenger 3	200	-	-	-	-	2	-	7.7
	-	250	-	20	-	1	2	-
1st Cleaner	-	-	-	-	-	1	5	-
2nd Cleaner	-	-	-	-	-	1	4	-

Test No. 19 - Continued

Observations:

Ro Conc 1 and 2	Stibnite with fine quartz and quartz middling pyrite depressed
Scavenger 1 and 2	pyrite beginning to float stibnite "flocs"
Scavenger 3	stibnite/pyrite floating strongly.
Scavenger Tail	some coarse stibnite remaining
Comments:	Dispersant mixture of alum, sodium sulphite and sodium silicate would appear to have a depressant effect on antimony flotation.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 2nd Cl Conc	2.39	64.5	58.8
2. 2nd Cl Tail	1.74	9.57	6.4
3. 1st Cl Tail	4.03	4.73	7.3
4. Scav Concentrate	3.79	9.33	13.5
5. Scav Tailing	88.05	0.42	14.
Head (Calc.)	100.00	2.62	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.13	41.4	65.2
Products 1 to 3	8.16	23.3	72.4
Products 1 to 4	11.95	18.8	85.9
Products 4 and 5	91.84	0.79	27.6

Mill Feed 1

Test No. 22

Purpose: To repeat Test 3 but clean the combined rougher and scavenger

Procedure: As below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne					Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	NaSil	Na2CO3	Grind	Cond.	Froth	
Grind	-	-	-	-	-	30	-	-	8.1
Rougher	250	40	5	-	-	-	2	5	7.8
	250	40	5	-	-	-	2	6	7.6
	250	40	-	-	-	-	2	5	7.6
1st Cleaner	-	-	-	-	-	-	1	5	7.7
	100	10	-	-	-	-	2	5	-
2nd Cleaner	-	-	-	-	-	-	1	5	7.7
	50	5	-	-	-	-	1	3 1/2	7.7
3rd Cleaner	-	-	-	25	23	-	2	5	8.2
	25	5	-	-	-	-	2	3 1/2	7.6

Stage	Rougher	1st and 2nd Cl	3rd Cleaner
Flotation Cell	1000 g D-1	500 g D-1	250 g D-1
Speed: r.p.m.	1800	1500	1200

Test No. 22 - Continued

Observations:

Ro Conc	Stibnite conspicuous in rougher tailing after 500 g/t $Pb(NO_3)_2$ and 100 g/t 3477 Required 3rd rougher stage Total rougher flotation 16 minutes stibnite, some pyrite and gangue slimes
Ro Tail	Clean some stibnite middling with quartz considerable pyrite
1st Cleaner	Require 100 g/t $Pb(NO_3)_2$ and 3477 is float conspicuous liberated stibnite very slow flotation
3rd Cl Conc 1	clean stibnite some pyrite main contaminant quartz with small attachments of stibnite. Some stibnite middlings with quartz
3rd Cl Conc 2	coarse liberated stibnite fine pyrite and quartz'
3rd Cl Tail	coarse liberated stibnite, coarse stibnite with quartz middlings, stibnite attachments on quartz, a circular stibnite intergrowth into quartz.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 3rd Cl Conc	4.80	46.3	85.2
2. Sb 3rd Cl Tail	1.44	5.06	2.8
3. Sb 2nd Cl Tail	4.23	1.31	2.1
4. Sb 1st Cl Tail	10.92	0.57	2.4
5. Rougher Tail	78.61	0.25	7.5
Head (Calc.)	100.00	2.61	100.0

Calculated Grades and Recoveries

Products 1 and 2	6.24	36.8	88.0
Products 1 to 3	10.47	22.5	90.1
Products 1 to 4	21.39	11.3	92.5

Mill Feed 1

Test No. 23

Purpose: To repeat conditions of Test 22 but replace 3477 with 3501 and investigaste cleaning with A3-3

Procedure: As below.

Feed: ~2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	A3-3	$Pb(NO_3)_2$	3501	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Rougher	-	250	40	20	-	2	5	7.8
	-	250	60	-	-	2	6	7.7
Scavenger	-	250	40	-	-	2	5	7.7
1st Cleaner	-	-	-	-	-	1	8	7.7
2nd Cleaner	-	-	-	-	-	1	5	7.7
	-	25	-	-	-	2	2	-
3rd Cleaner	25	-	-	-	-	2	5	7.7
	-	15	-	-	-	2	2	-
4th Cleaner	25	10	-	15	-	2	5	7.4

Test No. 23 - Continued

Observations:

Ro Conc	3501 stronger than 3477 Most of stibnite floated with 100 g/t 3401. Coarse stibnite and quartz middlings in rougher tailing. concentrate contained more pyrite and quartz than Test 22
Scavenger Conc	very low grade considerable pyrite and quartz 1/2 stibnite present as liberated grains 1/2 stibnite quartz/stibnite middling
1st Cl Tail	low weight but liberated average size stibnite
2nd Cl Tail	considerable liberated stibnite pyrite quartz Added 250 g/t $Pb(NO_3)_2$ with no collector and produced excellent stibnite froth product
Final 2nd Cl Tail	low weight, very little stibnite, clean coarse pyrite and quartz
3rd Cleaner	Froth went white after 5 min with A3-3. In rougher and cleaners 1 and 2 black stibnite always coloured froth
4th Cleaner	$Pb(NO_3)_2$ added before flotation improved flotation considerably. 1st froth >65% Sb but almost entire cell floated
Comments:	3501 not advantageous over 3477 $Pb(NO_3)_2$ additions required in cleaning to activate coarse or average size stibnite A3-3: $Al_2(SO_4)_3$, Na_2SO_3 & Na Silicate not advantageous.

Test No 23 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 4th Cl Conc	3.48	59.6	81.1
2. Sb 4th Cl Tail	0.11	15.8	0.7
3. Sb 3rd Cl Tail	0.68	6.23	1.7
4. Sb 2nd Cl Tail	2.31	1.41	1.2
5. Sb 1st Cl Tail	9.81	1.29	4.9
6. Scav Conc	3.14	1.04	1.3
7. Scav Tail	80.47	0.29	9.1
Head (Calc.)	100.00	2.56	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.59	58.3	81.8
Products 1 to 3	4.27	50.0	83.5
Products 1 to 4	6.58	32.9	84.7
Products 1 to 5	16.39	14.0	89.6
Products 1 to 6	19.53	11.9	90.9
Products 6 and 7	83.61	0.32	10.4

Mill Feed 1

Test No. 24

Purpose: To repeat conditions of Test 22 with $CuSO_4$

Procedure: As below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$CuSO_4$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	
Rougher	250	40	15	-	2	5	7.5
Strong pyrite float, test discarded.							

Mill Feed 1

Test No. 25

Purpose: To examine xanthated fatty acid collector using ethyl in place of amyl xanthate

Procedure: Clean rougher and scavenger

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	A3-3	$Pb(NO_3)_2$	A325 / FA1 / OP6	Octyl Alcohol	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	8.1
Condition	250	-	-	-	-	3	-	8.1
	-	300	-	-	-	2	-	7.8
Rougher 1	-	-	20	-	-	2	5	-
Rougher 2	-	100	10	-	-	2	-	-
	-	100	-	10	-	2	3 1/2	-
	-	-	10	-	-	1	3	-
Rougher 3	250	-	-	-	-	3	-	-
	-	200	-	-	-	2	-	7.7
	-	-	40	-	-	2	2	-
	-	-	20	5	-	2	-	-
1st Cleaner	200	-	-	-	-	3	-	7.9
	-	100	-	-	-	2	5	-
2nd Cleaner	200	-	-	-	-	3	5	7.9
3rd Cleaner	100	-	-	-	-	3	3 1/2	-

Stage	Rougher	1st Cleaner	2nd and 3rd Cleaner
Flotation Cell	1000 g D-1	500 g D-1	250 g D-1
Speed: r.p.m.	1800	1500	1200

Test No. 25 - Continued

Observations:	(binocular microscope)
Ro Conc 1	strong pyrite float stibnite
Ro Conc. 2	no flotation with 100 g/t $Pb(NO_3)_2$ and xanthated fatty acid additional $Pb(NO_3)_2$ floated pyrite, stibnite and quartz
Ro Conc. 3	coarse stibnite, pyrite >40% Sb
1st Cl Tail	quartz - pyrite
2nd Cl Tail	pyrite, quartz, some stibnite
3rd Cl Tail	pyrite, coarse stibnite
3rd Cl Conc	considerable pyrite in concentrate

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cl Conc	3.25	57.4	76.5
2. 3rd Cl Tail	1.33	12.6	6.9
3. 2nd Cl Tail	2.35	2.67	2.6
4. 1st Cl Tail	8.79	1.22	4.4
5. Ro Tail	84.28	0.28	9.6
Head (Calc.)	100.00	2.44	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.58	44.4	83.4
Products 1 to 3	6.93	30.2	86.0
Products 1 to 4	15.72	14.0	90.4

Mill Feed 1

Test No. 27

Purpose: To investigate the effect of a high initial dose of $Pb(NO_3)_2$, scavenge and clean with SO_2 at pH 6.8.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$Pb(NO_3)_2$	3477	SO2	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Rougher 1	500	-	-	-	-	5	-	7.6
	-	100	-	20	-	1	6	7.7
Rougher 2	200	-	-	-	-	2	-	7.6
	-	20	-	-	-	1	2	-
Rougher 3	200	-	-	-	-	2	-	-
	-	20	-	-	-		3 1/2	-
Rougher 4	-	-	150	-	-	2	2	6.9-7.3
Rougher 5	-	-	150	-	-	1	-	-
	-	20	-	-	-	1	2	6.7-7.2
1st Cleaner 1	-	-	75	-	-	1	5	6.8-7.4
1st Cleaner 2	-	-	75	-	-	1	-	6.5
	-	10	-	-	-	1	3	6.6
2nd Cleaner 1	-	-	75	-	-	1	4	6.5-7.2
2nd Cleaner 2	-	5	-	-	-	1	2	7.2
2nd Cleaner 3	25	-	-	-	-	3	-	7.4
	-	5	-	-	-	1	1 1/2	-
3rd Cleaner	-	-	50	-	-	1	4 1/2	6.4-7.4
4th Cleaner	-	-	25	-	-	1	4	6.1-7.2

Stage	Rougher	1st Cleaner	2nd and 3rd Cleaner
Flotation Cell	1000 g D-1	500 g D-1	250 g D-1
Speed: r.p.m.	1800	1500	1200

Test No. 27 - Continued

Observations:	(binocular microscope)
Ro Conc 1	froth very poor at start of flotation pyrite, quartz in tolerable amounts fine to coarse stibnite
Ro Conc. 2	coarse stibnite few pyrite grains quartz slime
Ro Conc. 3	similar to Ro Conc. 2 SO_2 to pH 6.8, increased to pH 7.3 during Ro 4
Ro Conc. 4	free stibnite and quartz SO_2 to pH 6.8 and 20 o/t 3477 increased to pH 7.2
Ro Conc. 5	low grade stibnite
Rougher tailing	cleanest tailing to date
1st Cl Conc 1	stibnite, consierable pyrite
1st Cl Conc 2	stibnite, considerable quartz slimes fine pyrite
2nd Cl Conc 2	very very light float
2nd Cl Conc 3	dirty with pyrite and slime
2nd Cl Tail	dark stibnite, darker than float stibnite/quartz middling good pyrite rejection some fibrous stibnite some coarse stibnite and coarse rounded stibnite grains

Test No. 27 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 4th Cl Conc	3.19	63.4	81.3
2. 4th Cl Tail	0.30	20.7	2.5
3. 3rd Cl Tail	0.80	7.15	2.3
4. 2nd Cl Tail	6.19	1.43	3.5
5. 1st Cl Tail	15.51	0.76	4.7
6. Ro Tail	74.01	0.19	5.7
Head (Calc.)	100.00	2.49	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.49	59.7	83.8
Products 1 to 3	4.29	49.9	86.1
Products 1 to 4	10.48	21.3	89.6
Products 1 to 5	25.99	9.03	94.3

Mill Feed 1

Test No. 28

Purpose: To investigate the effect of a 1000 g/t addition of $Pb(NO_3)_2$ in the rougher

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	A3-3	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Rougher	1000	-	-	-	-	5	-	7.2
	-	120	50	-	-	1	7	7.3
1st Cleaner	-	-	5	-	-	1	5	-
	100	-	-	-	-	3	3	7.7
2nd Cleaner	50	-	10	-	-	3	4	7.4
3rd Cleaner	-	-	-	25	-	3	5	7.3
	25	-	-	-	-	2	2	-

Test No. 28 - Continued

Observations: (binocular microscope)

Rougher Tail	excellent
Ro Conc	pyrite
1st Cleaner 2	100 g/t $Pb(NO_3)_2$ essential to float liberated stibnite
2nd Cleaner and 3rd Cleaner necessary	$Pb(NO_3)_2$

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cl Conc	3.87	53.7	84.3
2. 3rd Cl Tail	1.16	5.70	2.7
3. 2nd Cl Tail	1.56	2.38	1.5
4. 1st Cl Tail	10.11	0.75	3.1
5. Ro Tail	83.30	0.25	8.4
Head (Calc.)	100.00	2.47	100.0

Calculated Grades and Recoveries

Products 1 and 2	5.03	42.6	87.0
Products 1 to 3	6.59	33.1	88.5
Products 1 to 4	16.70	13.5	91.6

Mill Feed 1

Test No. 29

Purpose: To repeat conditions of Test 8 but clean combined rougher and scavenger 4 times.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	2044	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	-
Rougher	250	40	20	-	2	5	7.4
	250	40	-	-	2	5	-
Scavenger	250	40	-	-	2	5	-
1st Cleaner	-	5	-	-	1	5	7.4
	100	5	-	-	2	3	-
2nd Cleaner	50	5	10	-	2	5	-
3rd Cleaner	25	-	-	-	2	4	7.1
4th Cleaner	25	-	-	-	2	4	-

Test No. 29 - Continued

Observations:

Scavenger Tail	quartz, pyrite few liberated stibnite particles and middling with quartz
Scavenger Conc	stibnite with quartz and liberated pyrite
1st Cleaner Tail	good rejection of quartz- pyrite some stibnite middling with quartz
4th Cleaner Tail	pyrite and quartz - quartz middling some liberated coarse stibnite

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 4th Cl Conc	3.62	58.6	83.4
2. 4th Cl Tail	0.41	12.7	2.0
3. 3rd Cl Tail	0.75	4.64	1.4
4. 2nd Cl Tail	1.59	1.65	1.0
5. 1st Cl Tail	9.67	1.28	4.9
6. Ro Tail	83.96	0.22	7.3
Head (Calc.)	100.00	2.54	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.03	53.9	85.4
Products 1 to 3	4.78	46.2	86.8
Products 1 to 4	6.37	35.1	87.8
Products 1 to 5	16.04	14.7	92.7

Mill Feed 1

Test No. 30

Purpose: To repeat conditions of Test 29 but regrind the scavenger concentrate and combine with the rougher before cleaning

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh mill feed 1

Grind: 30 minutes at 60% solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	2044	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	-
Rougher	250	40	20	-	2	5	7.5
	250	40	-	-	2	5	-
Scavenger	250	40	-	-	2	5	-
Regrind Scavenger Conc		-	-	5	-	-	-
1st Cleaner	-	5	-	-	1	5	7.6
	100	5	5	-	2	3	-
2nd Cleaner	50	5	10	-	2	5	7.4
3rd Cleaner	25	-	-	-	2	4	7.3
4th Cleaner	25	-	-	-	2	4	7.0

Test No. 30 - Continued

Observations:

1st Cleaner Tail — quartz and pyrite
middling with quartz
few corase liberated Sb.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 4th Cl Conc	4.24	52.9	85.5
2. 4th Cl Tail	0.60	7.23	1.7
3. 3rd Cl Tail	1.17	2.32	1.0
4. 2nd Cl Tail	4.83	1.11	2.0
5. 1st Cl Tail	15.49	0.70	4.1
6. Scav Tail	73.67	0.20	5.7
Head (Calc.)	100.00	2.62	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.84	47.2	87.2
Products 1 to 3	6.01	38.5	88.2
Products 1 to 4	10.84	21.8	90.2
Products 1 to 5	26.33	9.40	94.3

Mill Feed 2

Test No. 20

Purpose: To repeat conditions of Test 3 on Mill Feed 2

Procedure: As outlined below

Feed: 2000 grams minus 10 mesh mill feed 2

Grind: 30 minutes at 60 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	7.9
Rougher	250	40	10	-	2	5	7.6
	250	20	-	-	2	5	-
Scavenger	250	40	-	-	2	5	-
1st Cleaner	-	5	-	-	1	5	7.6
	100	5	5	-	2	3	-
2nd Cleaner	50	5	-	-	2	5	7.1
3rd Cleaner	25	-	5	-	2	4	7.5

Observations:

Scavenger Tail	small amount of middling quartz
Scavenger Conc	Liberated stibnite, coarse quartz and pyrite, with quartz mostly abundant stibnite floating as "flocs"
Ro Conc	principal gangue is quartz
1st Cleaner Tail	quartz, some pyrite stibnite middling with quartz
Cleaner Concentrate	some quartz and pyrite remain

Test No. 20 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cl Conc	3.5	59.9	69.4
2. 3rd Cl Tail	0.3	9.25	0.9
3. 2nd Cl Tail	0.9	3.29	1.0
4. 1st Cl Tail	2.1	1.77	1.2
5. Scav Conc	5.9	9.78	19.1
6. Scav Tail	87.3	0.29	8.4
Head (Calc.)	100.00	3.02	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.8	55.9	70.3
Products 1 to 3	4.7	45.8	71.3
Products 1 to 4	6.8	32.2	72.5
Products 1 to 5	12.7	21.8	91.6
Products 5 and 6	93.2	0.89	27.5

Screen Analysis

Combined Products

Mesh Size (Tyler)	% Retained Individual	% Retained Cumulative	% Passing Cumulative
+ 65	.6	.6	99.4
100	2.7	3.3	96.7
150	8.2	11.5	88.5
200	12.8	24.3	75.7
270	12.6	36.9	63.1
400	11.9	48.8	51.2
- 400	51.2	100.0	-
Total	100.0	-	-

Mill Feed 2

Test No. 21

Purpose: To repeat conditions of Test 20 but reduce $Pb(NO_3)_2$ collector in cleaning stages

Procedure: As outlined below

Feed: 2000 grams minus 10 mesh mill feed 2

Grind: 30 minutes at 60 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	2	5	7.8
Rougher	250	40	10	-	2	5	7.4
	250	20	-	-	2	5	-
Scavenger	250	40	-	-	2	5	-
1st Cleaner	-	-	-	-	1	5	7.5
	-	5	5	-	2	3	-
2nd Cleaner	-	-	-	-	1	5	-
3rd Cleaner	-	-	-	-	1	4	7.4

Observations:

1st Cleaner Tail: more pyrite than test 20
coarse liberated stibnite

3rd Cleaner Tail: high grade coarse stibnite

3rd Cleaner Conc: very little pyrite

Test 21 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. 3rd Cl Conc	1.9	67.6	42.2
2. 3rd Cl Tail	1.4	61.3	128.2
3. 2nd Cl Tail	1.1	16.5	6.0
4. 1st Cl Tail	3.2	2.26	2.4
5. Scav Tail	9.4	4.59	14.2
6. Scav Tail	83.0	0.26	7.0
Head (Calc.)	100.00	3.04	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.3	64.9	70.4
Products 1 to 3	4.4	52.8	76.4
Products 1 to 4	7.6	31.5	78.8
Products 1 to 5	17.0	16.6	93.0
Products 5 and 6	92.4	0.71	21.2

Mill Feed 2

Test No. 26

Purpose: To improve the flotation of Mill Feed 2 with increased collector additions. Add $Pb(NO_3)_2$ to cleaning stages.

Procedure: As outlined below

Feed: 1000 grams minus 10 mesh mill feed 2

Grind: 15 minutes at 60 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	$Pb(NO_3)_2$	3477	Octyl Alcohol	A3-3	A325 / FA1 / OP6	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	-	-	15	-	-	-
Rougher 1	300	-	-	-	-	-	-	2	-	7.5
	-	40	40	-	-	-	-	1	4	-
Rougher 2	150	-	-	-	-	-	-	2	-	-
	-	40	15	-	-	-	-	1	3	-
Rougher 3	150	-	-	-	-	-	-	2	-	-
	-	40	-	-	-	5	-	1	3	-
Scavenger	-	-	-	250	-	-	-	3	-	8.0
	200	-	-	-	-	-	-	2	-	7.6
	-	-	-	-	40	-	-	1	3	-
Scav 1st Cl	-	-	-	150	-	-	-	2	-	8.0
	100	-	-	-	-	-	-	2	2	-
Ro 1st Cl	50	-	-	-	-	-	-	2	3	7.6
	-	20	10	-	-	5	-	1	3	-
Ro 2nd Cl	25	-	-	-	-	-	-	2	2	7.4
	-	10	10	-	-	-	-	-	-	-

Stage	Ro + Scav	Scav 1st Cl
Flotation Cell	500 g D-1	250 g D-1

Test No. 26 - Continued

Observations:

Ro Conc 1	Excellent high grade Sb
Ro Conc 2	Fine stibnite and considerable quartz
Ro Conc 3	Similar to Ro Conc 2
Scav Conc	Considerable pyrite, some stibnite
Scav Tail	quartz, some pyrite few middling stibnite grains
Scav 1st Cl Tail	quartz
Scav 1st Cl Conc	pyrite, quartz and stibnite
Ro 1st Cl Tail	quartz some stibnite middling and coarse grains few pyrite grains

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Ro 2nd Cl Conc	4.33	54.9	82.9
2. Ro 2nd Cl Tail	2.06	4.08	2.9
3. Ro 1st Cl Tail	12.41	1.15	5.0
4. Scav 1st Cl Conc	3.66	2.54	3.2
5. Scav 1st Cl Tail	7.79	0.50	1.4
6. Scav Tail	69.75	0.19	4.6
Head (Calc.)	100.00	2.87	100.0

Calculated Grades and Recoveries

Products 1 and 2	6.39	38.5	85.8
Products 1 to 3	18.80	13.9	90.8
Products 4 and 5	11.45	1.15	4.6
Products 1 to 5	30.25	9.04	95.4
Products 4 to 6	81.20	0.33	9.2

Native Antimony

Test No. 7

Purpose: To repeat Test 6 but on the native antimony sample

Procedure: As below

Feed: 2 Kg -10 mesh native antimony ore

Grind: 20 + 7 + 5 minutes in rod mill at 66% solids

Conditions:

Stage	Reagents Added, grams per tonne					Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	NaHS	A325	Grind	Cond.	Froth	
Grind	-	-	-	-	-	20	-	-	-
Screen at 100 mesh									
Grind O/S 1 min per 200 g	-	-	-	-	-	7	-	-	-
Screen at 100 mesh									
Grind O/S 1 min per 200 g	-	-	-	-	-	5	-	-	-
Condition	-	-	-	-	-	-	2	-	7.6
Rougher 1	250	-	-	-	-	-	2	-	7.4
	-	40	5	-	-	-	1	5	7.4
Rougher 2	250	-	-	-	-	-	2	-	7.2
	$CuSO_4$	40	-	-	-	-	1	5	-
Rougher 3	-	-	-	250	-	-	5	-	8.6
	500	-	-	-	-	-	2	-	7.0
	-	40	-	-	-	-	1	4	-
Rougher 4	-	-	-	-	20	-	-	2	7.4
Rougher 5	-	-	-	500	-	-	5	-	8.8
	500	-	-	-	40	-	3	4	7.4

Observations: (binocular microscope)

Ro Conc 1 — Flotation considerably slower in last 4 minutes than in 1st minute.
Very little gangue.

Ro Conc 2 — Froth barren
considerable oxidized sulfides
some middling with quartz
gangue primarily quartz.

Test No. 7 - Continued

Ro Conc 3	Strong pyrite float
Ro Conc 4	Strong pyrite float Less stibnite/antimony than Ro 3
Ro Conc. 5	strong pyrite float
Ro Tailing	Free native antimony and possibly stibnite.
Comments	The NaHS + $CuSO_4$ depressed the antimony minerals, possibly because of the high pH.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Ro Conc 1	4.36	54.6	46.5
2. Ro Conc 2	4.59	6.95	6.2
3. Ro Conc 3 to 5	9.65	1.80	3.4
4. Ro Tail	81.40	2.76	43.9
Head (Calc.)	100.00	45.12	100.0

Calculated Grades and Recoveries

Products 1 and 2	8.95	30.2	52.7
Products 1 to 3	18.60	15.4	56.1

Test No. 7 - Continued

Screen Analysis

Combined Products

Particle Size	% Retained		% Passing
	Individual	Cumulative	Cumulative
+ 100M	8.6	8.6	91.4
150	16.6	25.2	74.8
200	13.3	38.5	61.5
37.5um	15.4	53.9	46.1
29.1	7.4	61.3	38.7
20.3	6.6	67.9	32.1
14.0	5.4	73.3	26.7
10.8	2.5	75.8	24.2
- 10.8	24.2	100.0	-
Total	100.0	-	-

Specific Gravity 2.88

Native Antimony

Test No. 10

Purpose: To repeat conditions of Test 9 but increase reagent aditions for the native antimony sample

Procedure: As outlined below

Feed: 2000 grams minus 10 mesh native antimony sample

Grind: 30 minutes at 60% solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$CuSO_4$	A325	MIBC	A350	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	7.8
Rougher 1	500	-	-	-	-	2	-	6.8
	-	40	40	-	-	1	5	7.2
Rougher 2	250	-	-	-	-	2	-	7.0
	-	-	-	40	-	1	5	-

Observations:

1. Native antimony in tail.

2. More antimony floated than in test 7 but also more pyrite.

Test products discarded, not asayed.

Native Antimony

Test No. 11

Purpose: To investigate the use of Pb acetate, octyl alcohol and AF25/3477 at acid pH 6.5

Procedure: As outlined below

Feed: 2000 grams minus 10 mesh native antimony sample

Grind: 30 minutes at 60 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne					Time, minutes			pH
	Pb Acetate	H_2SO_4	AF25* / 3477	Octyl Alcohol	A350* / FA3	Grind	Cond.	Froth	
Grind	-	-	-	-	-	30	-	-	-
Condition	300	500	-	-	-	-	2	-	6.5
Rougher	-	-	30	6	-	-	2	8	-
	300	200	-	-	-	-	4	-	6.5
	-	-	15	6	-	-	2	4	-
Scavenger	-	-	-	-	15	-	-	8	-
1st Cleaner	300	-	-	-	-	-	2	5	-

* AF25/3477 1:1 ** A350/FA3 80:20 with warm water

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 1st Cl Conc	3.69	41.5	31.9
2. Sb 1st Cl Tail	3.64	11.4	8.6
3. Scavenger Conc	7.15	4.64	6.9
4. Scavenger Tail	85.52	2.95	52.6
Head (Calc.)	100.00	4.80	100.0

Calculated Grades and Recoveries

Products 1 and 2	7.33	26.6	40.5
Products 1 to 3	14.48	15.7	47.4

Native Antimony

Test No. 12

Purpose: To investigate the use of depressant A3-3 and collector A350/FA-3 with $CuSO_4$ activation

Procedure: As outlined below

Feed: 2000 grams minus 10 mesh native antimony

Grind: 30 minutes at 60 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne					Time, minutes			pH
	A3-3*	$CuSO_4$	A350**/FA3	MIBC	Octyl Alcohol	Grind	Cond.	Froth	
Grind	-	-	-	-	-	30	-	-	-
Rougher	150	-	-	-	10	-	5	-	8.2
	-	300	25	40	-	-	2	8	7.0
	-	20	5	-	-	-	2	4	-
1st Cleaner	-	-	-	-	-	-	1	5	-
2nd Cleaner	25	-	-	-	-	-	1	4	7.4

* 1:2:3 Al_2SO_4 : Na_2SO_3 : Na_2SiO_3 ** 80 : 20 AX350 : FA3 in warm water

Test No. 12 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 2nd Cl Conc	6.01	75.3	89.0
2. Sb 2nd Cl Tail	1.30	9.36	2.4
3. Sb 1st Cl Tail	5.91	1.84	2.1
4. Sb Ro Tail	86.78	0.38	6.5
Head (Calc.)	100.00	5.09	100.0

Calculated Grades and Recoveries

Products 1 and 2	7.31	63.6	91.4
Products 1 to 3	13.22	36.0	93.5

Test No. 12 - Continued

Screen Analysis

Rougher Tail

Particle Size	% Retained Individual	% Retained Cumulative	% Passing Cumulative
+ 65M	1.7	1.7	98.3
100	4.8	6.5	93.5
150	10.8	17.3	82.7
200	13.9	31.2	68.8
270	13.4	44.6	55.4
400	12.0	56.6	43.4
28.7 um	5.1	61.7	38.3
20.1	7.4	69.1	30.9
13.8	6.1	75.2	24.8
10.7	2.3	77.5	22.5
- 10.7	22.5	100.0	-
Total	100.0	-	-

Specific Gravity 2.79

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. + 100M	6.5	0.38	6.5
2. -100 +200 M	24.7	0.32	20.8
3. -200 + 400 M	25.4	0.34	22.7
4. -400 + 20 um	12.5	0.35	11.5
5. -20 + 11 um	8.4	0.13	2.9
6. - 11 um (calc)	22.5	0.60	35.6
Head direct	100.00	0.38	100.0

Native Antimony

Test No. 13

Purpose: To investigate the effect of increasing the A3-3 addition.

Procedure: As outlined below

Feed: 2000 grams minus 10 mesh native antimony

Grind: 30 minutes at 60 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne					Time, minutes			pH
	A3-3	Octyl Alcohol	CuSO4	A350 / FA3	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	-	30	-	-	8.4
Condition	200	6	-	-	-	-	10	-	8.4
	-	-	300	-	-	-	3	-	7.0
Rougher	-	-	-	25	30	-	2	5	7.4
	-	-	50	5	-	-	2	3	-
1st Cleaner	50	-	-	-	5	-	2	5	-
	-	-	-	5	-	-	1	2	-
2nd Cleaner	25	-	-	-	-	-	2	5	7.0

Observations

The mixture of AX 350 and FA3 had partially separated and was not as selective against pyrite.
A stability agent, possibly Lannagol OP6 should be examined for the xanthated fatty acid and/or more power should be used in the initial preparation.
Reblending the mixture did not produce as homogenous a mixture as the initial preparation.
The increased additions of A3-3 may also have increased antimony losses to the tailing.

Comments

Conditioning time with the A3-3 mixture may be important.

Test No. 13 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 2nd Cl Conc	9.18	37.2	68.2
2. Sb 2nd Cl Tail	1.69	22.4	7.6
3. Sb 1st Cl Tail	5.01	8.46	8.5
4. Sb Ro Tail	84.12	0.94	15.7
Head (Calc.)	100.00	5.01	100.0

Calculated Grades and Recoveries

Products 1 and 2	10.87	34.9	75.8
Products 1 to 3	15.88	26.6	84.3

Native Antimony

Test No. 14

Purpose: To investigate the effect of decreasing the A3-3 addition.

Procedure: As outlined below

Feed: 2000 grams minus 10 mesh native antimony

Grind: 30 minutes at 60 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne					Time, minutes			pH
	A3-3	Octyl Alcohol	CuSO4	A350 / FA3	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	-	30	-	-	-
Condition	100	10	-	-	-	-	3	-	8.3
Rougher	-	-	250	10	10	-	2	2	-
	-	-	-	5	10	-	-	2	-
	-	-	-	2.5	-	-	-	2	-
	-	-	-	2.5	7.5	-	-	2	-
Scavenger	-	-	50	5	-	-	2	2	-
1st Cleaner	50	-	-	-	-	-	2	7	7.4
2nd Cleaner	-	-	-	-	-	-	2	5	7.2

Test No. 14 - Continued

Observations

Excellent high grade concentrate
Native antimony in tailing
Collector mixture preparation should be evaluated, as discussed in Test 13.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 2nd Cl Conc	3.20	81.7	53.1
2. Sb 2nd Cl Tail	1.64	27.5	9.2
3. Sb 1st Cl Tail	6.04	5.14	6.3
4. Sb Ro Tail	89.12	1.74	31.4
Head (Calc.)	100.00	4.93	100.0

Calculated Grades and Recoveries

Products 1 and 2	4.84	63.3	62.3
Products 1 to 3	10.88	31.0	68.6

Native Antimony

Test No. 15

Purpose: To examine xanthated FA1 stabilized with Lannagol OP 6 and use lead nitrate in place of copper sulphate

Procedure: As below

Feed: 2000 grams minus 10 mesh native antimony

Grind: 30 minutes at 60 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	A3-3	$Pb(NO_3)_2$	AF350* / FA1	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	8.2
Rougher	150	-	-	-	-	5	-	8.1
	-	300	-	-	-	2	-	7.6
	-	-	25	40	-	1	5	7.8
Scavenger	50	-	-	-	-	2	-	7.6
	-	100	-	-	-	2	-	7.5
	-	-	8	-	-	1	4	7.6

* 72 A350 : 18FA1 : 10 Lannagol OP6

Test No. 15 - Continued

Observations

Rougher Tail	mainly quartz some pyrite small amount of liberated Sb
Rougher Conc	Froth strong liberated stibnite and middling with quartz abundant pyrite some pyrite with quartz
Scavenger Conc	mostly pyrite some Sb and middling with quartz Quartz
Scavenger Tail	some coarse pitted Sb remaining
Comments	The pyrite was activated. In test 12 the pyrite was not as activated. The probable cause was FAl rather than $Pb(NO_3)_2$. Recommend reduce collector addition to test 16 and increase A3-3.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Rougher Conc	13.63	32.7	91.0
2. Rougher Tail	86.37	0.51	9.0
Head (Calc.)	100.00	4.90	100.0

Native Antimony

Test No. 16

Purpose: Similar to Test 15 but reduce the amount of collector to the rougher, increase the amount of depressant and reduce the depressant conditioning time

Procedure:

Feed: 1000 grams minus 10 mesh native antimony

Grind: 15 minutes at 50 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne							Time, minutes			pH
	A3-3	$Pb(NO_3)_2$	AF350*/FA1	MIBC	SO_2	$Ca(OH)_2$	Na_2CO_3	Grind	Cond.	Froth	
Grind	-	-	-	-	-	-	-	15	-	-	
Rougher 1	500	-	-	-	-	-	-	-	2	-	7.6
	-	250	-	-	-	-	-	-	2	-	7.2
	-	-	20	15	-	-	-	-	1	5	-
Rougher 2	100	-	-	-	-	-	-	-	2	-	7.4
	-	-	-	-	125	-	-	-	3	3	6.5
Rougher 3	-	-	-	-	2500	-	-	-	5	-	3.5 - 4.3
	-	-	-	-	-	1000	-	-	1	2	6.3
Rougher 4	-	-	-	-	-	-	750	-	1	-	6.5
	-	50	-	-	-	-	-	-	2	-	-
	-	-	5	-	-	-	-	-	1	2	5.8
	-	-	-	-	-	-	400	-	2	1	6.5

* 72 A350 : 18 FA1 : 10 Lannagol OP6

Test No. 16 - Continued

Observations

Rougher Conc 1	native antimony stibnite pyrite starting to float after about 2 minutes
Rougher Conc 2	strong pyrite float
Rougher Conc 3	native antimony and stibnite but light weight
Rougher Conc 4	pyrrhotite, native antimony and stibnite
Rougher Tailing	clean tailing with considerable pyrite

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Ro Conc 1	7.81	49.0	77.0
2. Ro Conc 2	3.26	8.54	5.6
3. Ro Conc 3	0.47	59.7	5.6
4. Ro Conc 4	87.31	0.19	3.4
Head (Calc.)	100.00	4.97	100.0

Calculated Grades and Recoveries

Products 1 and 2	11.07	37.1	82.6
Products 1 to 3	11.54	38.0	88.2
Products 1 to 4	12.69	37.8	96.6

Native Antimony

Test No. 17

Purpose: To investigate the use of an SO_2/lime circuit on native antimony flotation

Procedure: As outlined below. Use lime to adjust pH over 6.0 then use soda ash to maintain 6.5.

Feed: 1000 grams minus 10 mesh native antimony sample

Grind: 15 minutes at 50 percent solids in the lab ball mill

Conditions:

Stage	Reagents Added, grams per tonne						Time, minutes			pH
	SO_2	$Ca(OH)2$	Na_2CO_3	$Pb(NO_3)_2$	3477	AX350	Grind	Cond.	Froth	
Grind	-	-	-	-	-	-	15	-	-	7.5
Conditioner	4500	-	-	-	-	-	-	5	-	3.5-4.2
	-	2000	1000	-	-	-	-	1	-	>6.5
Rougher	-	-	2000	250	40	8	-	1	4	6.7
Scavenger	-	-	1000	250	-	8	-	1	4	7.0

Test No. 17 - Continued

Observations

Scavenger Tail	coarse liberated stibnite slime (from mill) assayed separately.
Scavenger Conc	coarse stibnite pyrite
Rougher Conc	high grade stibnite with FA no flotation with 3477
Comments	pH control >6.5 necessary for pyrite depression. Excessive reagent requirements. Test terminated.

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Ro Conc 1	5.69	64.5	76.2
2. Scavenger Conc	1.88	16.0	6.2
3. Mill Slimes	1.49	4.50	1.4
4. Scavenger Tail	90.94	0.86	16.2
Head (Calc.)	100.00	4.82	100.0

Calculated Grades and Recoveries

Products 1 and 2	7.57	52.5	82.4
Products 1 to 3	9.06	44.6	83.8
Products 3 and 4	92.43	0.92	17.6

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A Division of Falconbridge Limited
Lakefield, Ontario

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LAKEFIELD RESEARCH
A DIVISION OF FALCONBRIDGE LIMITED
LAKEFIELD, ONTARIO, CANADA

Open File Report 89-2

AN INVESTIGATION OF THE RECOVERY OF ANTIMONY FROM SAMPLES SUBMITTED BY DURHAM RESOURCES INC.

PROGRESS REPORT NO. 2

by

Lakefield Research
A Division of Falconbridge Limited

Canada-New Brunswick Mineral Development Agreement
Entente Canada-Nouveau-Brunswick L'Exploitation Minérale

Natural Resources and Energy New Brunswick
Ressources Naturelles et Énergie Nouveau-Brunswick
Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

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New Brunswick

Hon. Morris Green, Minister

1989

AN INVESTIGATION OF THE RECOVERY OF ANTIMONY FROM SAMPLES SUBMITTED BY DURHAM RESOURCES INC.

PROGRESS REPORT NO. 2

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An Investigation of

THE RECOVERY OF ANTIMONY

from samples

submitted by

DURHAM RESOURCES INC.

Progress Report No. 2

Project No. L.R. 3161

NOTE:

This report refers to the samples as received.

The practice of this Company in issuing reports of this nature is to require the recipient not to publish the report or any part thereof without the written consent of Lakefield Research.

LAKEFIELD RESEARCH
A DIVISION OF FALCONBRIDGE LIMITED
December 15, 1986

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A B S T R A C T

Flotation tests were conducted on a sample of mill feed assaying 2.74 % Sb. Mineralogical examination indicated that the antimony mineral composition of the sample was 81 % stibnite, 10 % berthierite, 5 % native antimony and 4 % gudmundite.

The results showed that conditioning the rougher feed pulp with sulphuric acid to pH 6.5 improved antimony flotation.

The final cleaner concentrates assayed 67 - 69 % Sb at 80 - 83 % recovery in batch tests.

Antimony losses in the flotation tailings were attributed to finely dispersed middling grains and -10 μm slime.

INTRODUCTION

On September 4, 1986 a sample of mill feed to the Lake George antimony concentrator, representing the milling period from August 15 to August 20, was received at Lakefield Research.

In a telephone conversation on August 14 Mr. Victor Hendricken of Durham Resources discussed the changing mineralogy of the mill feed, as determined by the Research and Productivity Council, and the subsequent effect on mill performance.

The native antimony and berthierite, $FeSb_2S_4$, contents of the mill feed were variable but increasing. Various stopes contained 10-30 % of the antimony as native antimony and 10 - 20 % as berthierite. The concentrator was recovering 90 - 95 % of the stibnite content of the ore but only 50 % of the berthierite and less than 50 % of the native antimony, as determined by quantitative mineralogical examination at RPC.

Mr. Hendricken requested flotation testwork on a current sample of mill feed which should contain more native antimony and berthierite than mill feeds 1 and 2, reported in Progress Report No. 1.

Current concentrator performance was a concentrate grade of 59 - 67 % Sb from a 2 % Sb feed assay. Mill tailings could range from 0.4 to 0.7 % Sb over 24 hours.

Introduction - Cont'd

In a subsequent telephone conversation on October 15, Mr. Hendricken reported that the concentrator performance had stabilized and concentrate grades of 60 - 63 % Sb were being produced at 86 - 88 % recovery. The mill tailing assay was down to 0.3 % Sb.

LAKEFIELD RESEARCH

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SUMMARY

1. Head Analysis

A representative sample of mill feed 3 assayed 2.74 % Sb, 0.37 % As, 0.012 % Pb and 2.33 % S.

2. Mineralogy

A sample of mill feed, representative of mill feed 3, was sent by Mr. Mr. Hendricken directly to the Research and Productivity Council in Fredericton, New Brunswick for mineralogical examination.

The examination showed that the distribution of antimony minerals in the sample was as follows (1):

Mineral	Formula	Mineral Distribution	Locked Grains
Stibnite	Sb_2S_3	81 %	23 %
Native antimony	Sb	5 %	60 %
Berthierite	$FeSb_2S_4$	10 %	60 %
Gudmundite	FeSbS	4 %	50 %

Stibnite and berthierite represented 91 % of the antimony minerals in the sample.

23 % of the stibnite and 60 % of the berthierite were present as locked grains. Most of the locked stibnite occurred as small inclusions (<20 μm diameter) within gangue and represented < 10 % of the locked grain. Most of the locked berthierite occurred as fine needles and blebs (< 20 μm diameter) within gangue and also represented < 10 % of the locked grains.

(1) J. Melluish, RPC Mineralogical Report M/86/023, September 16, 1986

Summary - Continued

3. Flotation

3.1. Rougher Flotation

A series of rougher flotation tests were conducted to examine the effect of sulphuric acid, lead nitrate and 3477 collector additions on antimony and arsenic flotation.

The results which are contained in Table No. 1 indicated that conditioning the rougher feed pulp with sulphuric acid to pH 6.5 improved antimony flotation. Arsenic flotation was also increased. This data confirmed the results by Davis et al(2). They suggested that berthierite and gudmundite flotation were both improved at lower pH.

There was a large variation in the amount of weight floated with the sulphuric acid addition. Rougher concentrate weight recovery ranged from 10 to 25 % at 88 to 94 % Sb recovery. The 1st cleaner tailing contained most of the excess gangue floated in the rougher concentrate and the system had stabilized after two cleaning stages.

Several identical tests did not reduce the range of weight floated in the rougher concentrate. It was concluded that the rougher reagent system was sufficiently powerful to collect the locked mineral grains. Dilution in cleaning weakened the collector bond and the locked grains were not floated.

(2) D.R. Davis et al, Antimony in South Africa, J.S Afr. Inst. Min. Metall. Vol. 86, No. 6, June 1986, pp 173-193

Summary - Continued

3.1. Rougher Flotation - Cont'd

Table No. 1 - Rougher Flotation

Test No.	Grind Size %-200 Mesh	H_2SO_4 g/t	$Pb(NO_3)_2$ g/t	3477 g/t	Rougher Concentrate					Investigation
					Wgt. %	Assay, %		% Distr.		
						Sb	As	Sb	As	
36	80	-	500	40	17.5	9.7	-	61.0	-	Reagents
42	80	-	625	40	14.4	16.0	0.37	82.7	14.0	
33	80	-	625	80	21.7	12.0	0.37	91.7	22.2	
34	80	200	625	80	25.0	10.3	0.57	92.7	36.5	Reagents
38	80	500	375	40	21.6	8.7	-	77.3	-	Reagents
39	80	500	500	60	18.3	13.8	-	91.1	-	
37	80	500	625	40	25.3	10.3	-	94.3	-	
35	80	500	625	80	25.0	10.2	0.64	92.9	43.2	
44	90	500	625	40	24.4	10.9	-	94.0	-	Grind
41	80	500	625	40	10.4	23.7	0.62	88.4	17.8	Reproducibility
45	80	500	625	40	11.2	22.9	0.65	90.9	19.9	
40	80	500	625	40	17.1	13.9	-	87.5	-	
43	80	500	625	40	24.5	11.0	-	93.6	-	
37	80	500	625	40	25.3	10.3	-	94.3	-	

3.2. Cleaner Flotation

Lead nitrate additions were required throughout cleaner flotation to maintain antimony recovery. Sulphuric acid additions to maintain pH 6.2-6.5 in cleaner flotation reduced antimony grade.

The best results were achieved at a primary grind of 80 % -200 mesh with 500 g/t H_2SO_4, 625 g/t $Pb(NO_3)_2$ and 40 g/t 3477 in rougher flotation at pH 6.5 followed by 90 g/t $Pb(NO_3)_2$ additions (total) to cleaner flotation at natural pH 7.0 - 7.2

The final cleaner concentrate assayed 67 - 69 % Sb at 80 - 83 % recovery.

Similar flotation conditions at natural pH in the rougher produced about 5 % lower antimony recovery.

The arsenic analyses of the cleaner concentrate ranged from 0.15 % to 0.20 % As regardless of sulphuric additions to the rougher.

The results are contained in Table No. 2.

Summary - Continued

3.2. Cleaner Flotation - Cont'd

Table No. 2 - Cleaner Flotation

Test	Grind Size	Rougher Flotation								Cleaner Flotation							Head Head Assay %	
		Conditions			Rougher Concentrate					Conditions		3rd Cl. Concentrate						
						Assay %		% Distr.					Assay %		% Distr.		(Calc.)	
No.	%-200 Mesh	H_2SO_4 g/t	$Pb(NO_3)_2$ g/t	3477 g/t	Wgt. %	Sb	As	Sb	As	H_2SO_4 g/t	$Pb(NO_3)_2$ g/t	Wgt. %	Sb	As	Sb	As	Sb	As
40	80	500	625	40	17.1	13.9	-	87.5	-	-	-	1.9	66.5	-	47.1	-	2.71	-
41	80	500	625	40	10.4	23.7	0.62	88.4	17.8	-	90	3.3	67.0	0.20	79.8	1.8	2.79	0.36
42	80	-	625	40	14.4	16.0	0.37	82.7	14.0	-	90	3.1	66.9	0.16	75.2	1.2	2.78	0.38
43	80	500	625	40	24.5	11.0	-	93.6	-	325	90	4.7	53.4	-	87.7	-	2.87	-
45	80	500	625	40	11.2	22.9	0.65	90.9	19.9	-	90	3.4	68.4	0.17	83.1	1.6	2.83	0.37

DISCUSSION AND RECOMMENDATIONS

Reduced pH with sulphuric acid appeared to improve berthierite flotation and might be beneficial in closed circuit mill flotation.

The main cause of antimony loss in the flotation tailings was the presense of <20 µm inclusions of stibnite, berthierite, native antimony and gudmundite in the mill feed. The exposed surface of the antimony minerals in the locked grains was less than 10 % of the total surface of the locked grain.

Because of the relative friability of antimony minerals in general these locked grains should be considered as unrecoverable.

SAMPLE PREPARATION

On September 4, 1986, four pails of damp mill feed representing the milling period August 15 to August 20 were received at Lakefield Research and given Reference Number 8626761.

The contents of the pails were combined, dried, cone and roll crushed to -10 mesh and riffled into 2 kg test charges and a head sample for analysis.

The sample was labelled mill feed 3.

INVENTORY

A total of 32 x 2 kg test charges of mill feed 3 remain on hand at Lakefield.

DETAILS OF TESTS

Test No. 31

Purpose: To investigate flotation of Mill Feed 3 under standard flotation conditions.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 percent solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne					Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Na_2SO_3	A350/ FA1/OP6	Grind	Cond.	Froth	
Grind	-	-	-	-	-	30	-	-	-
Rougher	250	40	10	-	-	-	2	5	7.5
	250	20	-	-	-	-	2	5	-
	125	20	-	-	-	-	2	5	-
Scavenger	-	-	-	250	-	-	2	-	7.7
	-	-	-	-	20	-	2	3	-
Ro. 1st Cl.	100	-	5	-	-	-	2	5	6.9
	-	5	-	-	-	-	1	3	-
Ro. 2nd Cl.	50	5	-	-	-	-	2	5	6.7
Ro. 3rd Cl.	30	-	-	-	-	-	2	4	6.7
Scav. 1st Cl.	-	-	-	100	-	-	1	3	7.8
Scav. 2nd Cl.	-	-	-	-	-	-	1	-	7.3

Test No. 31 - Continued

Metallurgical Results

Product	Weight	Assays, %	% Distribution
	%	Sb	Sb
1. Sb Ro. 3rd Cl. Conc.	4.69	52.5	89.7
2. Sb Ro. 3rd Cl. Tail.	0.64	2.78	0.6
3. Sb Ro. 2nd Cl. Tail.	1.85	1.05	0.7
4. Sb Ro. 1st Cl. Tail.	9.93	0.58	2.1
5. Sb Scav. 2nd Cl. Conc.	1.18	1.76	0.8
6. Sb Scav. 2nd Cl. Tail.	0.67	2.08	0.5
7. Sb scav. 1st Cl. Tail.	1.91	0.94	0.7
8. Sb Scav. Tailing	79.13	0.17	4.9
Head (Calculated)	100.00	2.74	100.0

Calculated Grades and Recoveries

Products 1 and 2	5.33	46.5	90.3
Products 1 to 3	7.18	34.8	91.0
Products 1 to 4	17.11	15.0	93.1
Products 5 and 6	1.85	1.88	1.3
Products 5 to 7	3.76	1.40	2.0
Products 5 to 8	82.89	0.23	6.9
Products 1 and 5	5.87	43.9	93.9

Test No. 32

Purpose: To investigate flotation of Mill Feed 3 using A3-3 and $CuSO_4$.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 60 percent solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	A3-3	$CuSO_4$	A350/ FA1/OP6	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Rougher	150	-	-	-	-	5	-	7.4
	-	300	25	40	-	2	8	6.9
	-	20	5	-	-	2	4	-
1st Cleaner	25	-	-	-	-	1	7	7.1
2nd Cleaner	-	-	-	-	-	1	4	-

Metallurgical Results

Product	Weight	Assays, %	% Distribution
	%	Sb	Sb
1. Sb 2nd Cl. Conc.	5.98	14.0	30.8
2. Sb 2nd Cl. Tail.	2.10	3.67	2.8
3. Sb 1st Cl. Tail.	9.80	1.96	7.1
4. Sb Rougher Tail.	82.12	1.96	59.3
Head (Calculated)	100.00	2.72	100.0

Calculated Grades and Recoveries

Products 1 and 2	8.08	11.3	33.6
Products 1 to 3	17.88	6.19	40.7

Test No. 33

Purpose: To investigate rougher flotation.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	-
Rougher 1	250	40	10	-	2	5	7.4
Rougher 2	250	20	-	-	2	5	-
Rougher 3	125	20	-	-	2	5	-

Test No. 33 - Continued

3161-33 Metallurgical Balance

Product	Weight %	Assays,% Sb	As	% Distribution Sb	As
1. Ro Conc 1	6.80	18.70	0.47	45.05	8.82
2. Ro Conc 2	7.24	13.60	0.31	34.87	6.19
3. Ro Conc 3	7.61	4.36	0.34	11.75	7.14
4. Ro Tail	78.35	0.30	0.36	8.33	77.84
Head(calc)	100.00	2.82	0.36	100.00	100.00
Combined Products					
1+2	14.04	16.07	0.39	79.92	15.02
1to 3	21.65	11.95	0.37	91.67	22.16

Test No. 34

Purpose: To investigate rougher flotation at pH 7.0.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	H_2SO_4	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Condition	-	-	-	200	-	5	-	7.0
Rougher 1	250	40	10	-	-	2	5	6.8
Rougher 2	250	20	-	-	-	2	5	6.8
Rougher 3	125	20	-	-	-	2	5	7.0

Test No. 34 - Continued

3161-34 Metallurgical Balance

Product	Weight %	Assays,% Sb	As	% Distribution Sb	As
1. Ro Conc 1	9.22	16.00	1.04	53.18	24.62
2. Ro Conc 2	9.83	10.40	0.30	36.86	7.57
3. Ro Conc 3	6.00	1.23	0.28	2.66	4.32
4. Ro Tail	74.94	0.27	0.33	7.29	63.49
Head(calc)	100.00	2.77	0.39	100.00	100.00
Combined Products					
1+2	19.05	13.11	0.66	90.04	32.19
1to 3	25.06	10.26	0.57	92.71	36.51

Test No. 35

Purpose: To investigate rougher flotation at pH 6.5

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	H_2SO_4	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Condition	-	-	-	500	-	5	-	6.5
Rougher 1	250	40	10	-	-	2	5	6.4
Rougher 2	250	20	-	-	-	2	5	6.5
Rougher 3	125	20	-	50	-	2	5	6.5

Test No. 35 - Continued

3161-35 Metallurgical Balance

Product	Weight %	Assays,% Sb	Assays,% As	% Distribution Sb	% Distribution As
1. Ro Conc 1	12.14	13.50	1.05	59.51	34.49
2. Ro Conc 2	9.72	9.20	0.25	32.46	6.57
3. Ro Conc 3	3.14	0.83	0.25	0.95	2.12
4. Ro Tail	75.00	0.26	0.28	7.08	56.81
Head(calc)	**100.00**	**2.75**	**0.37**	**100.00**	**100.00**
Combined Products					
1+2	**21.86**	**11.59**	**0.69**	**91.97**	**41.06**
1to3	**25.00**	**10.24**	**0.64**	**92.92**	**43.19**

Test No. 36

Purpose: To examine the effect of reducing collector levels in roughing at natural pH.

Procedure: As outlined below.

Feed: 2000 g minus 10 mesh.

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	-
Rougher 1	250	20	20	-	2	5	-
Rougher 2	125	10	-	-	2	5	-
Rougher 3	125	10	5	-	2	5	-

Metallurgical Results

Product	Weight	Assays, %	% Distribution
	%	Sb	Sb
1. Ro. Concentrate 1	6.80	15.1	36.8
2. Ro. Concentrate 2	5.43	6.81	13.3
3. Ro. Concentrate 3	5.24	5.78	10.9
4. Rougher Tailing	82.53	1.32	39.0
Head (Calculated)	100.00	2.79	100.0

Calculated Grades and Recoveries

Products 1 and 2	12.23	11.4	50.1
Products 1 to 3	17.47	9.73	61.0

Test No. 37

Purpose: To repeat conditions of test No. 35 with reduced collector.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	H_2SO_4	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Condition	-	-	-	500	-	5	-	6.5
Rougher 1	250	20	10	-	-	2	5	-
Rougher 2	250	10	10	-	-	2	5	-
Rougher 3	125	10	-	-	-	2	5	-

Metallurgical Results

Product	Weight	Assays, %	% Distribution
	%	Sb	Sb
1. Rougher Conc. 1	10.21	13.4	49.5
2. Rougher Conc. 2	7.75	12.3	34.5
3. Rougher Conc. 3	7.35	3.87	10.3
4. Rougher Tail.	74.69	0.21	5.7
Head (Calculated)	100.00	2.76	100.0

Calculated Grades and Recoveries

Products 1 and 2	17.96	12.9	84.0
Products 1 to 3	25.31	10.3	94.3

Test No. 38

Purpose: To repeat conditions of test No. 37 with reduced $Pb(NO_3)_2$.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	H_2SO_4	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Condition	-	-	-	500	-	5	-	6.5
Rougher 1	125	20	10	-	-	2	5	-
Rougher 2	125	10	7.5	-	-	2	5	-
Rougher 3	125	10	-	-	-	2	5	-

Metallurgical Results

Product	Weight	Assays, %	% Distribution
	%	Sb	Sb
1. Rougher Conc. 1	8.19	12.2	35.7
2. Rougher Conc. 2	5.73	9.24	18.9
3. Rougher Conc. 3	7.67	4.64	12.7
4. Rougher Tailing	78.41	1.17	32.7
Head (Calculated)	100.00	2.80	100.0

Calculated Grades and Recoveries

Products 1 and 2	13.92	11.0	54.6
Products 1 to 3	21.59	8.73	77.3

Test No. 39

Purpose: To repeat rougher conditions of test No. 35 and clean combined rougher concentrates 1 and 2.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	H_2SO_4	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Condition	-	-	-	500	-	5	-	6.5
Rougher	250	40	10	-	-	2	5	6.9
	250	20	-	-	-	2	5	-
1st Cleaner	50	-	7.5	-	-	2	4	6.9
2nd Cleaner	25	-	5	-	-	2	4	7.0
3rd Cleaner	15	-	-	-	-	2	4	7.2

Metallurgical Results

Product	Weight	Assays, %	% Distribution
	%	Sb	Sb
1. 3rd Cleaner Conc.	4.25	54.4	83.5
2. 3rd Cleaner Tail.	0.83	3.00	0.9
3. 2nd Cleaner Tail.	1.94	1.19	0.8
4. 1st Cleaner Tail.	11.31	1.45	5.9
5. Rougher Tail.	81.66	0.30	8.9
Head (Calculated)	100.00	2.77	100.0

Calculated Grades and Recoveries

Products 1 and 2	5.09	45.9	84.4
Products 1 to 3	7.03	33.6	85.2
Products 1 to 4	18.34	13.8	91.1

Test No. 40

Purpose: To repeat conditions of test No. 37 but clean without further reagent additions.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	H_2SO_4	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	7.9
Condition	500	-	-	-	-	5	-	6.4
Rougher	-	250	20	17.5	-	2	5	6.9
	-	250	10	10	-	2	5	-
	-	125	10	-	-	2	5	-
1st Cleaner	-	-	-	-	-	2	10	7.3
2nd Cleaner	-	-	-	-	-	2	8	7.4
3rd Cleaner	-	-	-	5	-	2	8	-

Metallurgical Results

Product	Weight	Assays, %	% Distribution
	%	Sb	Sb
1. Sb 3rd Cl. Conc.	1.92	66.5	47.1
2. Sb 3rd Cl. Tail.	0.24	31.2	2.8
3. Sb 2nd Cl. Tail.	1.08	7.80	3.1
4. Sb 1st Cl. Tail.	13.83	6.75	34.5
5. Rougher Tail.	82.93	0.41	12.5
Head (Calculated)	100.00	2.71	100.0

Calculated Grades and Recoveries

Products 1 and 2	2.16	62.6	49.9
Products 1 to 3	3.24	44.3	53.0
Products 1 to 4	17.07	13.9	87.5

Test No. 41

Purpose: To repeat conditions of test No. 40 but use $Pb(NO_3)_2$ in cleaners as per test No. 39.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	H_2SO_4	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	7.9
Condition	500	-	-	-	-	5	-	6.4
Rougher	-	250	20	17.5	-	2	5	6.9
	-	250	10	10	-	2	5	-
	-	125	10	-	-	2	5	-
1st Cleaner	-	50	-	-	-	2	8	7.0
2nd Cleaner	-	25	-	5	-	2	6	7.1
3rd Cleaner	-	15	-	-	-	2	6	6.9

Metallurgical Results

Product	Weight	Assays, %		% Distribution	
	%	Sb	As	Sb	As
1. Sb 3rd Cl. Conc.	3.32	67.0	0.20	79.8	1.8
2. Sb 3rd Cl. Tail.	0.21	24.1	1.20	1.8	0.7
3. Sb 2nd Cl. Tail.	0.79	7.59	0.80	2.2	1.8
4. Sb 1st Cl. Tail.	6.06	2.13	0.80	4.6	13.5
5. Rougher Tail.	89.62	0.36	0.33	11.6	82.2
Head (Calculated)	100.00	2.79	0.36	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.53	64.4	0.26	81.6	2.5
Products 1 to 3	4.32	54.1	0.36	83.8	4.3
Products 1 to 4	10.38	23.7	0.62	88.4	17.8

Test No. 41 - Continued

Rougher Tailing

Metallurgical Results

Product	Weight	Assays, %	% Distribution
	%	Sb	Sb
1. +74 µm	21.3	0.45	26.7
2. -74 +37 µm	27.1	0.27	20.3
3. -37 +23 µm	13.3	0.22	8.1
4. -23 +12 µm	13.6	0.13	4.9
5. -12 µm	24.7	0.58	40.0
Head (Calculated)	100.0	0.36	100.0

NOTE: 40 % of the antimony losses in rougher tailing were as -12 µm

Test No. 42

Purpose: To repeat conditions of test No. 41 at natural pH

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne			Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	30	-	-	-
Condition	-	-	-	-	5	-	7.8
Rougher	250	20	17.5	-	2	5	-
	250	10	10	-	2	5	-
	125	10	-	-	2	5	-
1st Cleaner	50	-	-	-	2	8	7.6
2nd Cleaner	25	-	5	-	2	6	7.7
3rd Cleaner	15	-	-	-	2	6	-

Stage	Rougher	1st Cleaner	2nd and 3rd Cleaner
Flotation Cell	1000 gD-1	500 g D-1	250 g D-1

Metallurgical Results

Product	Weight	Assays, %		% Distribution	
	%	Sb	As	Sb	As
1. 3rd Cl. Conc.	3.12	66.9	0.15	75.2	1.2
2. 3rd Cl. Tail.	0.45	13.2	0.48	2.1	0.6
3. 2nd Cl. Tail.	2.03	2.52	0.47	1.8	2.5
4. 1st Cl. Tail.	8.77	1.13	0.42	3.6	9.7
5. Rougher Tail.	85.63	0.56	0.38	17.3	86.0
Head (Calc.)	100.0	2.78	0.38	100.0	100.0

Calculated Grades and Recoveries

Products 1 and 2	3.57	60.1	0.19	77.3	1.8
Products 1 to 3	5.60	39.2	0.29	79.1	4.3
Products 1 to 4	14.37	16.0	0.37	82.7	14.0

Test No. 43

Purpose: To repeat conditions of test No. 41 but clean at pH 6.5 with H_2SO_4.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	$Pb(NO_3)_2$	3477	MIBC	H_2SO_4	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Condition	-	-	-	500	-	5	-	6.5
Rougher	250	20	17.5	-	-	2	5	-
	250	10	10	-	-	2	5	-
	125	10	-	-	-	2	5	-
1st Cleaner	-	-	-	125	-	2	-	6.4
	50	-	-	-	-	2		6.5
2nd Cleaner	25	-	5	-	-	2	6	6.3
3rd Cleaner	-	-	-	75	-	2	-	6.2
	15	-	-	-	-	2	6	-

Test No. 43 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 3rd Cl. Conc.	4.71	53.4	87.7
2. Sb 3rd Cl. Tail.	1.55	3.59	1.9
3. Sb 2nd Cl. Tail.	4.31	1.20	1.8
4. Sb 1st Cl. Tail.	13.96	0.46	2.2
5. Sb Rougher Tail.	75.47	0.24	6.4
Head (Calculated)	100.00	2.87	100.0

Calculated Grades and Recoveries

Products 1 and 2	6.26	41.1	89.6
Products 1 to 3	10.57	24.8	91.4
Products 1 to 4	24.53	11.0	93.6

Screen Analyses

Combined Products

Mesh Size (Tyler)	% Retained Individual	% Retained Cumulative	% Passing Cumulative
+ 65	0.4	0.4	99.6
100	2.0	2.4	97.6
150	6.6	9.0	91.0
200	11.5	20.5	79.5
270	12.3	32.8	67.2
400	10.7	43.5	56.5
- 400	56.5	100.0	-
Total	100.0	-	-

Test No. 44

Purpose: To repeat conditions of test No. 41 with a finer grind.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 40 minutes at 59 % solids in the lab ball mill.

Conditions:

Stage	Reagents Added, grams per tonne				Time, minutes			pH
	H_2SO_4	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	40	-	-	-
Condition	500	-	-	-	-	5	-	6.5
Rougher	-	250	20	17.5	-	2	5	6.5
	-	250	10	10	-	2	5	-
	-	125	10	-	-	2	5	-
1st Cleaner	-	50	-	-	-	2	8	7.0
2nd Cleaner	-	25	-	5	-	2	6	7.1
3rd Cleaner	-	15	-	-	-	2	6	7.1

Test No. 44 - Continued

Metallurgical Results

Product	Weight %	Assays, % Sb	% Distribution Sb
1. Sb 3rd Cl. Conc.	4.74	53.0	88.6
2. Sb 3rd Cl. Tail.	0.98	2.26	0.8
3. Sb 2nd Cl. Tail.	3.91	1.29	1.8
4. Sb 1st Cl. Tail.	14.81	0.53	2.8
5. Sb Ro. Tailing	75.56	0.23	6.0
Head (Calculated)	100.00	2.84	100.0

Calculated Grades and Recoveries

Products 1 and 2	5.72	44.3	89.4
Products 1 to 3	9.63	26.8	91.2
Products 1 to 4	24.44	10.9	94.0

Screen Analyses

Combined Products

Mesh Size (Tyler)	% Retained Individual	% Retained Cumulative	% Passing Cumulative
+ 100	0.2	0.2	99.8
150	2.2	2.4	97.6
200	7.1	9.5	90.5
270	11.6	21.1	78.9
400	13.5	34.6	65.4
- 400	65.4	100.0	-
Total	100.0	-	-

Test No. 45

Purpose: To repeat conditions of test No. 41.

Procedure: As outlined below.

Feed: 2000 grams minus 10 mesh Mill Feed 3.

Grind: 30 minutes at 59 % solids in lab ball mill.

Conditions:

Time	Reagents Added, grams per tonne				Time, minutes			pH
	H_2SO_4	$Pb(NO_3)_2$	3477	MIBC	Grind	Cond.	Froth	
Grind	-	-	-	-	30	-	-	-
Condition	500	-	-	-	-	5	-	6.5
Rougher	-	250	20	17.5	-	2	5	-
	-	250	10	10	-	2	5	-
	-	125	10	-	-	2	5	-
1st Cleaner	-	50	-	5	-	2	8	-
2nd Cleaner	-	25	-	2.5	-	2	6	-
3rd Cleaner	-	15	-	-	-	2	6	-

Stage	Rougher	1st Cleaner	2nd and 3rd Cleaner
FlotationCell	1000 g D-1	500 g D-1	250 g D-1
Speed: r.p.m.	1650		

Test No. 45 - Continued

3161-45 Metallurgical Balance

Product	Weight %	Assays,% Sb	As	% Distribution Sb	As
1. Sb Cl Conc	3.44	68.40	0.17	83.11	1.60
2. Sb 3rd Cl Tail	0.50	19.60	1.62	3.44	2.20
3. Sb 2nd Cl Tail	1.03	5.00	1.23	1.82	3.46
4. Sb 1st Cl Tail	6.26	1.15	0.74	2.54	12.57
5. Ro Tail	88.77	0.29	0.33	9.09	80.07
Head(calc)	100.00	2.83	0.37	100.00	100.00
Combined Products					
1+2	3.94	62.24	0.35	86.55	3.80
1to3	4.97	50.37	0.53	88.37	7.27
1to4	11.23	22.93	0.85	90.91	19.93

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